DIVISION 400 -- LIGHTING, SIGNS, AND TRAFFIC CONTROL

SECTION 401 -- LIGHTING AND TRAFFIC SIGNAL GENERAL REQUIREMENTS

401.01 -- Description

1. The requirements in this Section apply when the Contractor furnishes and/or installs all or part of the following systems:

   a. Sign lighting system.

   b. Traffic signal system.

   c. Permanent lighting system.

   d. Temporary lighting system.

2. When the pay item listed in the Basis of Payment Subsection of each Section includes the word "Install", then the Department will furnish the item and the Contractor shall install it. If the word "Install" is not in the pay item listed in the Basis of Payment Subsection of each Section, then the Contractor shall furnish the item at no additional cost to the Department and install it.

401.02 -- Material Requirements

1. a. The Contractor shall, prior to ordering any material, submit to the NDR Construction Division, for approval, 7 copies of a list showing all lighting, sign, and traffic signal items to be used on the project. This list of items shall be known as the "Materials List."

2. All equipment and material must be approved before installation. Once approved, there shall be no substitutions for any of the items on the "Materials List" without a prior written request for a substitution and written approval by the Engineer. The Department shall not be liable for any equipment or materials ordered or purchased by the Contractor before approval.

3. Materials will be checked for compliance with the applicable submittals as required by Table 401.01.

4. The Contractor shall transfer all manufacturer's warranties and guarantees to the Department. All manufacturer's warranty and guarantee documentation and all operation and part manuals shall also be given to the Department.

5. All items shown on the "Materials List" will be checked for compliance with the plans and specifications. Two copies of the reviewed "List", showing approval or disapproval of each specific item, will be returned to the Contractor. If sufficient data is not available to determine compliance, additional data will be requested in the form of catalog cuts, test data, or actual samples.

6. The Contractor shall inform his/her supplier(s) that all items supplied to the project must be suitably stamped, stenciled, tagged, or otherwise marked to allow for easy identification with the descriptive markings, brand names, and catalog numbers shown on the "Materials List" and shop drawings.

7. The Contractor shall furnish samples, upon request, of any item or material to be furnished on the project. Unless destructive testing is required, the sample will be returned.

Table 401.01

Required Submittals					
	Item	Mfr.'s Model or Cat. No.	Shop Drawings	Certificate of Compliance	Other
a.	Traffic Signal Pole		X	X	
b.	Light Pole/Tower (Metal)		X	X	
c.	Pole (Wood)				*
d.	Anchor Bolt		X	X	
e.	Pull Box	X			
f.	Luminaire	X			**
g.	Photo Control	X			
h.	Power Foundation	X	X		
i.	Traffic Signal Controller	X			
j.	Street Lighting Control Cabinet	X			
k.	Signal Head	X			
l.	Ped. Pushbutton and Sign	X			
m.	Signal Mounting	X			
n.	Relay & Cabinet	X			
o.	Disconnect & Cabinet	X			
p.	Vehicle Detector	X			
q.	Vehicle Detector Sealant	X			
r.	Lamp	X			
s.	Electrical Wire and Cable	X			
t.	Conduit	X			
u.	Ground Rod	X			
v.	Mechanical Connector	X			
w.	Fuse Holder	X			
x.	Fuse	X			
y.	Expansion Coupling	X			
z.	Lightning Arrestor	X			
aa.	Recessed Junction Box	X			
bb.	Utility Pedestal	X			
cc.	Breakaway Device	X			
dd.	Grounding Connector	X			
ee.	Permanent Identification Tag	X			

* Manufacturer's data describing specie, size, class, and treatment.
** Photometric data base diskette in standard IES format.

8. All materials shall conform to the requirements of Table 401.02.

Table 401.02

Material Requirements	
Item	**Section**
Portland Cement Concrete	1002
Reinforcing Steel	1020
Gray Iron Castings	1051
Zinc Coating on Hardware	1059
Painting	1077
Light Standards	1073
Traffic Signal Standards	1073
Anchor Bolts	1073
Ground Rods	1073
High Mast Towers	1073
Control Centers	1073
Photoelectric Controls	1073
High Mast Luminaires and Lamps	1073
Wall Mounted Luminaires	1073
Electrical Wire and Cable	1073
Miscellaneous Materials	1073

9. a. The Contractor shall submit a written certification statement upon completion of lighting and traffic signal work. The statement shall be signed by the Contractor. The following is the required statement.

"The lighting and traffic signal materials installed are the materials specified in the contract or approved submittals. These lighting and traffic signal materials have been installed in accordance with the National Electric Code and other appropriate electrical safety codes."

b. All payments for lighting and traffic signal requirements will be deducted if the above certification statement is not received by the Project Manager.

401.03 -- Tests of Systems

1. a. The Contractor shall demonstrate to the Engineer's satisfaction that the complete system is in proper working order before final acceptance. The Contractor shall furnish all equipment and personnel necessary to perform operating circuit and resistance tests at no additional cost to the Department.

b. Each circuit's voltage and current readings shall be taken ahead of the contactor and in the base of the light pole furthest from the source.

c. Data from the above tests shall be furnished to the NDR Lighting Engineer in writing.

d. Resistance to ground shall be measured at random locations for noncurrent-carrying components, and insulation resistance tests shall be conducted when required by the Engineer.

2. The system shall be placed in normal operational mode after satisfactory completion of all required tests. Final acceptance will not be made until the system has operated satisfactorily for a period of not less than 14 days.

401.04 -- Grounding

1. a. All poles, controllers, and control centers shall be properly grounded by means of a copper clad ground rod and copper grounding electrode conductor.

b. Unless indicated otherwise, grounding conductors of No. 10 gauge or larger diameter wire shall be stranded.

2. a. All permanent lighting systems shall have a grounding conductor (equipment ground) installed throughout the system. A grounding conductor is usually not required in temporary lighting systems except that in some service areas the servicing electrical utility company may require a grounding conductor be used.

b. The grounding conductor shall be grounded at the control center and bonded to all poles, ground rods, and all non-current carrying components within the system.

c. The grounding conductor shall not be used for a neutral wire in the system and shall be tied to the AC neutral wire only in the controller cabinet or lighting control center.

3. When using a transformer type, breakaway base, the grounding conductor shall be attached to the breakaway base.

401.05 -- General Construction Requirements

1. Electrical Services:

a. In most instances, the electric services for a lighting system will be prearranged with the local utility and their locations shown in the plans. Services not predetermined shall be arranged for by the Contractor.

b. Electrical services for traffic signals will usually be arranged by the Contractor at the approximate locations shown in the plans.

c. Electric service locations shown in the plans are subject to changes in order to adapt to field conditions. Changes will be determined by the utility and the Engineer.

2. System Operation:

a. Workable segments of the installation shall be "turned on" and made to operate normally as soon as possible if the road is open to public travel.

b. The NDR Traffic or Lighting Engineer shall be notified at least 2 NDR work days before energizing any electrical system.

c. Electrical systems shall not be put into operation until the NDR Traffic or Lighting Engineer's authorized representative is present.

d. Unenergized circuits may be tested at any time.

e. Operation of the system shall not be construed as an acceptance of the system or any part of the system or as a waiver of any contract provisions.

f. The Contractor shall be fully responsible for proper operation of the system before final acceptance and shall remedy any defects or damages which may occur at no additional cost to the Department.

3. The installation shall be in accordance with the *National Electric Code* and all governing local ordinances and regulations. Roadway lighting and traffic signal systems are not subject to inspection by the state, county, or city electrical inspectors. Area lighting at weigh stations and rest areas are subject to this inspection.

4. All work shall be performed by competent tradespersons experienced in their craft and under the supervision of a licensed journeyperson electrician or lineperson. The licensed supervisor shall be on the job site whenever work is being performed. Any portion of the installation which presents an appearance of careless or shoddy work will be rejected.

5. The Contractor shall not attach or connect any equipment to any utility without specific permission from the owner of the facility. The Contractor shall contact the local electrical utility company 3 work days prior to installing any equipment on the utility's poles or requesting final service connections.

6. The Contractor shall replace and restore all plant materials and roadway structures disturbed by trenching, excavating, or backfilling operations. The Contractor shall dispose of all excess excavation and trenching material.

7. The Contractor shall be responsible for any tree trimming required.

8. The Contractor shall not be required to pay for electrical energy consumed by the permanent lighting system or traffic signal system.

9. With the exception of "Safety Lighting Systems", the Contractor shall not be required to pay for electrical energy consumed by temporary lighting systems.

10. The Contractor shall verify the location of all underground utilities as prescribed in the One Call Notification System Act.

401.06 -- Secondary Electrical Connections

1. Cable connections shall only be made in pull boxes, pole bases, luminaries, traffic signal heads, and junction boxes. Connections will not be allowed in earth or in conduit. All connections shall be made in accordance with the cable manufacturer's recommendations and the *National Electric Code*. Submersible, secondary, mechanical connectors meeting ANSI C119.1 are required in all pull boxes, on all detector circuits, and at other locations susceptible to moisture.

2. Cable connections at the control cabinet shall be made at the terminal boards provided for this purpose. All stranded wires inserted under a binder screw shall be equipped with a solderless pressure type spade connector. Only one wire shall be used with each spade connector. No more than 3 spade connectors shall be inserted under the same screw without specific approval of the Engineer. Spade connectors shall not be used on solid wire.

3. Breakaway Connectors:

a. "Breakaway Type" connectors shall be installed in each breakaway pole base as shown in the plans. Line and load sides of the connector shall be identified.

b. The phase conductor(s) shall be fused and shall have the female part of the connector on the line side.

c. The neutral conductor, when such is employed in the circuit, shall not be fused and shall have the female part of the connector on the load side.

4. An antioxidant compound shall be used on all dissimilar metal connections.

5. a. The Engineer may inspect 5 electrical connections at random.

b. If any of the 5 connections are found unacceptable, 10 additional connections shall be selected by the Engineer for inspection. If any of these connections are found unacceptable, the Contractor shall remake all connections on the project at no additional cost to the Department.

SECTION 402 -- ELECTRICAL WIRE AND CABLE IN CONDUIT

402.01 -- Description

The Contractor shall furnish and install electrical wire and cable of the size and type shown in the plans. This work includes the wire and cable, splices, connections, terminations, identification tags, and all labor, equipment, tools, materials, and incidentals required to complete the work.

402.02 -- Material Requirements

Traffic signal and roadway lighting conductors in conduit shall conform to the requirements of Section 1073. Conductors used as a neutral must be designated white or gray. Insulated equipment ground shall be green. Line conductors shall be designated red and black. Cable in Duct (CID) may be used in place of wire and cable only on roadway lighting and sign lighting systems and shall conform to the requirements of Section 1073.

402.03 -- Construction Methods

1. Unless indicated otherwise, all lighting systems shall be installed as conductors in conduit.

2. a. Conductors shall be installed in conduit only after the conduit system is completed and in place.

b. The conduit must be continuous, reasonably dry, completely free of debris, and without any sharp projections, edges, or short bends.

c. The Engineer may require the Contractor to demonstrate that the conduit is reasonably dry and free of debris by pulling a swab and/or mandrel through the conduit.

d. The wire and cable manufacturer's recommended maximum pulling tensions shall not be exceeded. If necessary, the cables shall be adequately lubricated to reduce friction and minimize possible damage. Lubricants shall be one of several commercially available wire pulling compounds that are suitable for the cables. They shall consist of soap, talc, mica, or similar materials and shall be designed to have no deleterious effects on the cables.

3. All cables shall be neatly trained to their destinations in cabinets, pole bases, transformer bases, pull boxes, junction boxes, or other enclosures. The destination of all cable runs shall be clearly identified by the use of permanent, non-ferrous or plastic tags stamped or embossed with the direction of the cable run and attached to the conduit in which the cable is housed. Conductor runs shall be tagged at all intermediate points along the run such as in pull boxes, junction boxes, pole bases, and transformer bases. In instances where the conduit housing the conductor is inaccessible, such as in anchor base pole installations, the identification tag shall be attached to the conductor itself.

4. The Contractor shall adhere to the ICEA recommended minimum values for wire and cable bending radii. These limits do not apply to conduit bends, sheaves, or other curved surfaces around which these cables may be pulled under tension while being installed. Larger radius bends are required for such conditions.

5. Where the cable enters or leaves the conduit, conduit bushings or bell ends shall be installed.

402.04 -- Method of Measurement

Electrical wire and cable shall be measured in linear feet from center to center of the pull boxes, poles, junction boxes, and controllers for each type and size shown in the plans. Cable in Duct (CID) will be measured as 2 separate items, conduit and cable.

402.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
2/C ____ Detector Lead-in Cable	Linear Foot (LF)
____ /C ____ Traffic Signal Cable	Linear Foot (LF)
Grounding Conductor	Linear Foot (LF)
_____ Pair Communication Cable	Linear Foot (LF)
Service Cable	Linear Foot (LF)
Street Lighting Cable, _____	Linear Foot (LF)
Roadway Lighting Cable, _____	Linear Foot (LF)
Street Lighting Cable, _____ Bare	Linear Foot (LF)
COAXIAL Cable	Linear Foot (LF) [Meter (m)]
Optical Detector Cable	Linear Foot (LF) [Meter (m)]

2. Payment is full compensation for all work prescribed in this Section.

SECTION 403 -- DIRECT BURIED WIRE AND CABLE

403.01 -- Description

1. The Contractor shall furnish and install direct buried electrical wire and cable of the size and type shown in the plans. This work includes the wire, cable, splices, connections, terminations, identification tags, trenching, backfilling, compacting, and all labor, equipment, tools, materials, and incidentals required to complete the work.

2. In some instances, the Contractor will be required to pick up and install utility supplied predicted cable. The size and type of cable, together with the pick up location, will be shown in the plans. Installation of the cable shall be according to guidelines issued by the utility.

403.02 -- Material Requirements

Direct buried cable and conductors for traffic signal and roadway lighting shall conform to the requirements of Section 1073. Cable used as a "neutral" shall be designated white or gray. Insulated equipment ground shall be green.

403.03 -- Construction Methods

1. The Contractor shall install the size and type of direct buried wire, cable, and predicted cable as shown in the plans.

2. The Contractor shall place the cables alongside the trench by moving the reel rather than pulling the cable from the reel and dragging the cable along the ground. Cables shall not be kinked or damaged during this operation.

3. The cables shall be lifted section by section and placed in the trench in such a manner as to prevent damage to the cables.

4. Cable shall be placed in trenches without dragging or stretching.

5. Cable shall be placed a minimum of 30 inches below ground level.

6. The bottom of the trench shall be firm and level. Sharp objects shall not protrude from the walls or the bottom of the trench.

7. Direct buried wire, cable, and predicted cable shall not be plow-pulled into place.

8. All trenches shall be backfilled as soon as practicable after placing the cable. The first lift of backfill material shall be a uniform thickness of approximately 6 inches. Care shall be exercised in compacting the backfill to prevent damage to the cable. The backfill shall be free of any material which could damage the cable. The remainder of the backfill shall be compacted to match the adjacent soil density so that the trench surface will remain level with the surrounding surfaces.

9. a. The cables shall be neatly trained to their destinations in cabinets, pole bases, pull boxes, and all other terminations.

b. The direction of each direct buried cable run shall be clearly identified with a stamped or embossed permanent plastic or non-ferrous metal tag at every point where the cable is accessible, such as in pull boxes, junction boxes, pole bases, transformer bases, and cabinets. A tag shall be attached to the conduit entrance bend whenever possible.

10. The minimum bending radii for cables or conductors less than 1 inch in diameter shall be 4 times the overall cable diameter. When using larger cables, the Contractor shall follow the ICEA recommended values. These limits do not apply to conduit bends.

11. Conduit bushings or bell ends shall be installed whenever the conductor enters or leaves a section of conduit or conduit bend.

403.04 -- Method of Measurement

Direct buried electrical wire, cable, and predicted cable shall be measured in linear feet from center to center of pull boxes, poles, junction boxes, cabinets, and controllers for each type and size shown in the plans.

403.05 -- Basis of Payment

1. **Pay Item** **Pay Unit**

2/C _____ Detector Lead-in Cable, Direct Buried	Linear Foot (LF)
___/C ____ Traffic Signal Cable, Direct Buried	Linear Foot (LF)
Service Cable, Direct Buried	Linear Foot (LF)
Direct Burial Cable, _____	Linear Foot (LF)
Install Predicted Cable	Linear Foot (LF)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 404 -- AERIAL CABLE

404.01 -- Description

The Contractor shall furnish and install electrical aerial cable of the size and type shown in the plans. This work includes the cable, mounting devices, splices, connections, terminations, and all labor, equipment, tools, materials, and incidentals required to complete the work.

404.02 -- Material Requirements

Traffic signal and roadway lighting aerial cable and conductors shall conform to the requirements of Section 1073.

404.03 -- Construction Methods

The Contractor shall install the aerial cable in strict compliance with the latest industry standards, practices, and procedures.

404.04 -- Method of Measurement

Aerial cable shall be measured in linear feet horizontally from center to center of the poles for each type and size of cable shown in the plans and shall not include allowances for vertical rises, drip loops, sags, or splices.

404.05 -- Basis of Payment

1.

Pay Item	Pay Unit
2/C _____ Detector Lead-in Cable, Aerial	Linear Foot (LF)
___/C ____ Traffic Signal Cable, Aerial	Linear Foot (LF)
Service Cable, _____ Aerial	Linear Foot (LF)
Street Lighting Cable, _____ Aerial	Linear Foot (LF)
COAXIAL Cable, Aerial	Linear Foot (LF) [Meter (m)]
Optical Detector Cable, Aerial	Linear Foot (LF) [Meter (m)]

2. Payment is full compensation for all work prescribed in this Section.

SECTION 405 -- CONDUIT

405.01 -- Description

1. The Contractor shall furnish and install the size and type of conduit shown in the plans. This applies to underground conduit and conduit in or on bridges, median barriers, retaining walls, tunnels, and similar structures. This work includes the conduit, fittings, excavating, backfilling, compacting, and all labor, equipment, tools, materials, and incidentals required to complete the work.

2. Special devices or fittings such as hangers, expansion fittings, deflection fittings, junction boxes, drains, grounding devices, and all other fittings required for a complete conduit system installation shall be considered subsidiary to the conduit pay item.

405.02 -- Material Requirements

Conduit and fittings shall conform to the requirements of Section 1073. The Contractor may use Cable in Duct (CID) in place of cable and conduit on lighting and sign lighting systems only, and the CID shall conform to the requirements of Section 1073.

405.03 -- Construction Methods

1. The Contractor shall assemble and install conduit systems in accordance with the *NEC*, except that in those instances where the *Standard Specifications* are more stringent than the minimum requirements of the *NEC*, the *Standard Specifications* shall prevail.

2. The Contractor may substitute a larger size conduit than specified at no additional cost to the Department if approved by the Engineer.

3. Fittings must be standard conduit fittings and designed for the specific type of conduit used. Galvanized malleable iron or steel fittings shall be used with galvanized rigid steel, intermediate metallic, or electrical metallic tubing conduit. Aluminum or zinc alloy fittings will not be allowed.

4. Field bends must be properly formed with appropriate tools and shall not reduce the conduit cross section area.

5. Exposed field cut threads on metallic conduit and any area where galvanizing has been removed shall be painted with 1 coat of an approved zinc rich paint.

6. All conduit terminations shall have bells or bushings.

7. Spare conduits shall be capped or plugged with standard fittings.

8. Unless otherwise provided or directed by the Engineer, underground conduit shall be placed 30 inches below finished grade.

9. The locations of conduit runs indicated in the plans may be altered at the direction of the Engineer to accommodate field conditions. Conduit shall be routed to minimize damage to existing trees and shrubs.

10. Trenches shall be excavated to true line and grade. Trench width shall be the minimum practical dimension needed to place the conduit. Backfill material shall be free of unsuitable materials. Backfill shall be placed with care

and shall be compacted and/or mounded so that, after natural settlement, the trench surface is level with the surrounding surface.

11. Conduit placed under surfaces which are not to be disturbed may be jacked or augured into the proposed location. Jacking pits shall be at least 2 feet beyond the edge of the pavement. Excessive use of water is not allowed.

12. Conduit installed in or on bridges, retaining walls, median barriers, tunnels, and similar structures shall be capped or plugged in an approved manner to prevent the entrance of water, concrete, or other foreign materials.

13. Conduit under sidewalk shall include replacement of the sidewalk from joint to joint unless the conduit is jacked under the sidewalk. Sidewalk that is damaged shall be removed and replaced as complete panels.

14. "Conduit Under Roadway" is conduit that is trenched in place before the roadway is paved. This conduit may be either metallic or nonmetallic. The Contractor may elect to trench through existing bituminous pavement to install conduit under the roadway before a new pavement is constructed.

15. Conduit under surfaced medians may be placed by jacking or augering. The Contractor may also elect to remove and replace the median surfacing and bury the conduit at no additional cost to the Department. Median surfacing shall be removed and replaced in complete panels from joint line to joint line.

16. Metallic junction boxes installed in bridges or median barriers shall be drilled and tapped to receive a grounding lug.

405.04 -- Method of Measurement

Conduit shall be measured in linear feet for each type and size shown in the plans. The length shall be measured horizontally from center to center of poles, pull boxes, junction boxes, and control cabinets and shall not include allowances for vertical rises or bends. Cable in Duct (CID) will be measured as 2 separate items, conduit and cable.

405.05 -- Basis of Payment

1. **Pay Item** **Pay Unit**

_____ Conduit in Trench	Linear Foot (LF)
_____ Conduit in Bridge	Linear Foot (LF)
_____ Conduit in Median Barrier	Linear Foot (LF)
_____ Conduit Under Median Surfacing	Linear Foot (LF)
_____ Conduit on Structure	Linear Foot (LF)
_____ Conduit Under Roadway	Linear Foot (LF)
_____ Conduit Under Sidewalk	Linear Foot (LF)
_____ Conduit, Jacked	Linear Foot (LF)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 406 -- PULL BOXES

406.01 -- Description

1. The Contractor shall construct pull boxes of the size, type, and at the locations shown in the plans and, if required, install a spare bend in the pull box as shown in the plans. This work shall include furnishing and installing the pull box, spare conduit bend, grounding connectors and ground rod (if required), washed rock, and all excavation, backfilling, compaction, labor, equipment, tools, and incidentals required to complete the work.

2. The Contractor shall relocate pull boxes as shown in the plans. A spare bend, if required, shall be installed in the relocated pull box as shown in the plans. "Relocate Pull Box, Type PB _____" shall include removing the existing pull box, installing the pull box at the new location, tapping into existing conduit, extending conduit to the relocated pull box, spare conduit bend(s), grounding connectors and ground rod(s) (if required), washed rock, and all excavation, backfilling, compaction, labor, equipment, tools, and incidentals required to complete the work.

406.02 -- Material Requirements

1. Pull boxes shall conform to the requirements shown in the plans.

2. Pull boxes shall be on the NDR Approved Products List.

406.03 -- Construction Methods

1. Pull boxes shall not be constructed in ditch bottoms, low areas where ponding of water may occur, or where they will be subjected to vehicular traffic.

2. Pull boxes shall not have concrete bottoms.

406.04 -- Method of Measurement

Pull boxes and relocated pull boxes shall be measured by the each.

406.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Pull Box, Type PB _____	Each (ea)
Relocate Pull Box, Type PB _____	Each (ea)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 407 -- POLE AND TOWER FOUNDATIONS

407.01 -- Description

1. Concrete Foundations (Conventional and High Mast):

a. Concrete foundations for poles and towers shall be of the size and type shown in the plans. Foundations shall include a ground rod(s), reinforcing steel, anchor bolts, conduit entrance bends, and a spare conduit bend (if required).

b. If the foundation details are not shown in the plans, the Contractor shall obtain the required soil data, design the foundation according to the soil test data, and construct the foundation. Two copies each of the soil test data and foundation design must be submitted to the Engineer before construction of the foundation will be allowed to begin.

c. The concrete foundation must be designed by a Professional Engineer registered in Nebraska. The Professional Engineer must stamp and sign all design documents.

2. Power Installed Foundations:

Power installed pole foundations may only be used when specified in the plans. Power installed foundations shall be of the size and type shown in the plans.

407.02 -- Material Requirements

1. Materials for use in concrete foundations shall conform to the requirements of Sections 1002 and 1020.

2. Anchor bolts shall conform to the requirements in Section 1073.

407.03 -- Construction Methods

1. a. The Engineer will stake the locations of all pole and tower foundations. Before constructing a foundation, it will be the Contractor's responsibility to verify that the staked location will not place the finished pole or tower in a conflict situation or at an elevation that would cause the amount of foundation above grade to conflict with specifications for the type of foundation being constructed.

b. Any locations or elevations that appear unreasonable or in conflict with specifications should be brought to the attention of the Engineer. The Engineer will review and decide any changes in location and/or elevation.

2. a. For conventional light poles, the Contractor shall construct the size and type of foundations shown in the plans.

b. For high mast towers, the Contractor shall construct foundations according to the design details shown in the plans or to those he/she has been required to furnish.

3. Concrete foundations for both pole and tower installations shall be constructed according to the following:

a. All foundation excavations shall be dry and free of loose dirt.

b. All concrete shall be Class 47B-2,900.

c. The anchor bolt pattern shall be centered in the foundation.

d. The Contractor shall perform all excavations, backfilling, and placing of reinforcing steel and concrete in accordance with Sections 702, 704, and 707.

4. a. The Contractor shall furnish and install power installed foundations in accordance with the manufacturer's instructions and details shown.

b. Foundations shall be installed before trenching for conduit or direct buried wire or cable.

c. The Contractor shall backfill and compact around the foundation to 95 percent of the maximum density as determined by NDR T 99.

407.04 -- Method of Measurement

1. If the pole or tower foundation design is shown in the plans, no measurements are necessary as the foundation is subsidiary to the pole and/or tower.

2. If the pole and tower foundation design is not shown in the plans:

a. The pole and tower foundation design is measured by the each per structure.

b. The pole and tower foundation concrete is measured by the cubic yard.

c. Reinforcing steel for the pole or tower foundation is measured by the pound.

3. Anchor bolts for the relocated pole and tower foundations are measured by the each.

407.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Foundation Design	Each (ea)
Concrete for Foundation	Cubic Yard (CY)
Reinforcing Steel	Pound (lb)
Anchor Bolts	Each (ea)

2. Pole and tower foundations shall be subsidiary to the pole and tower when the foundation design is provided in the plans.

3. Anchor bolts for new pole and tower foundations are subsidiary to the towers and poles.

4. Payment is full compensation for all work prescribed in this Section.

SECTION 408 -- POLES AND TOWERS

408.01 -- Description

1. The word "pole," when used in this Section, shall be taken to mean a lighting standard 50 feet or less in mounting height. Units with mounting heights greater than 50 feet will be referred to as "towers." Poles and towers have many different configurations. The type to be provided shall be as shown in the plans and described in the special provisions.

2. This Section describes the 3 general pole and tower requirements:

a. New Pole and Tower Installation:

(1) The Contractor shall furnish and install poles and towers of the size and type shown in the plans. Each pole and tower, complete with all of its components, shall be designed according to AASHTO, "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals" to withstand a 80 mph wind loading with a 1.3 gust factor.

(2) Conventional light poles, unless shown or stated otherwise, shall be furnished complete with pole shaft, base plate, mast arm(s), handhole with cover, anchor bolts with nuts, nut covers, luminaire(s), foundation, breakaway device (if required), in-line fuses and fuse holders, wire and cable in the pole and mast arm(s), and all excavation, backfilling, compaction, labor, tools, equipment, and incidentals necessary to complete the work.

(3) High mast towers, unless shown or stated otherwise, shall be furnished complete with tower shaft, base plate, handhole with cover, anchor bolts with nuts, high mast lowering system powered by an internal motor, electrical wires and cables, winch cable(s), hoisting cables, foundations, and all other items required to provide a complete and workable unit.

(4) All items associated with a lighting unit of either type must be compatible and work together to provide a reliable and efficient unit.

b. Pole and Tower Relocations:

(1) The Contractor shall relocate poles and towers as shown in the plans. Poles shall be carefully dismantled and all items stored and protected from damage until installed at their new locations. Towers shall be carefully lowered and stored on timber cribbing with the shaft in essentially straight alignment with no part of the unit in contact with the ground. The tower and its components shall be protected from damage until installed at their new location. The Engineer will designate specific areas for temporary storage of the material.

(2) Pole and tower relocations shall consist of removing the pole and/or tower with all associated items from its foundation and reinstalling the pole and/or tower on a new foundation at a new location together with removing or breaking back (removing the concrete pole foundation, including steel and anchor bolts to a minimum depth of 2 feet below finish grade) the old foundation and all necessary excavation, backfilling, removal of debris, compaction, labor, tools, equipment, and incidentals necessary to complete the work. Constructing a new concrete foundation, if required, is a part of this work.

c. Temporary Pole Installation:

(1) The Contractor shall install temporary poles as shown in the plans. Temporary poles are usually supplied by the Department.

(2) Items not furnished by the Department and required for a complete system will be furnished by the Contractor.

408.02 -- Material Requirements

1. Pole and tower materials shall conform to the requirements of Section 1073 and to the requirements shown in the plans.

2. a. Department-furnished poles and other lighting items and the locations where they are to be picked up are shown in the plans.

b. Items not furnished by the Department and required for a complete system shall be furnished by the Contractor.

c. The Contractor will contact the Engineer to determine when and where to pick up the State-furnished material. The Engineer will supply the Contractor with a completed "Stock Requisition." The Contractor will not be issued materials without a properly completed stock requisition.

3. The entire assembly shall meet all applicable local, county, state, and national codes.

408.03 -- Construction Methods

1. The Contractor shall assemble and install poles and towers in accordance with the manufacturer's instructions, plan details, or as directed by the Engineer.

2. a. All poles shall stand plumb under the dead load. If shimming is required, all shims shall be placed between the top of the foundation and the bottom of the transformer base (bottom of the pole base if no breakaway device is being used). Only regular "U" shaped shim stock shall be used and installed with the back edge of the shim flush with the bottom edge of transformer base or bottom edge of the pole base.

b. If concrete foundations are being used, the foundation shall be dressed to provide for proper seating and leveling.

c. Each pole shall be grounded to a ground rod and to the system grounding conductor.

3. Breakaway devices, when used on conventional pole installations, shall be installed in strict compliance with the manufacturer's details and instructions.

4. a. All towers shall be plumbed and supported by anchor bolts and nuts. The tower shall not rest on the concrete.

b. The space between the top of the concrete foundation and the bottom of the tower base shall be no greater than 2 anchor bolt diameters. This space shall not be grouted but shall be left open for ventilation and covered with a strip of expanded aluminum mesh as shown in the plans.

5. Mast arm signal and combination mast arm signal/lighting poles shall be leveled by the use of nuts and anchor bolts supplied with the pole. Before the pole is loaded, it shall be raked back in excess of the calculated deflection and plumbed after the loads are applied by adjusting the leveling nuts.

6. a. Poles and towers being relocated shall be installed at their new locations and connected electrically as shown in the plans.

b. Existing luminaires or traffic signals being reinstalled on relocated poles shall be cleaned and provided with new lamps.

c. Relocated towers shall have their luminaires cleaned and new lamps installed.

d. The Contractor shall install new wires with in-line fuses and fuse holders in the relocated pole shaft and new wires in the mast arm.

e. Missing or damaged components must be replaced by the Contractor.

7. a. Aluminum poles may be used in place of steel poles.

b. Design criteria for steel poles will apply to aluminum poles.

c. Aluminum poles shall have bases of cast aluminum.

d. All hardware used with aluminum poles, except the anchor bolts, shall be stainless steel.

8. Foundation dimensions and materials shall be as indicated in the plans. Anchor bolts shall be of the correct size and spacing for the pole(s) being furnished.

9. The cables exiting the pole shaft or mast arm shall have adequate drip loops. The wiring for the luminaires shall be installed with 40 inches of cable extending beyond the end of the mast arm.

10. a. Poles or other lighting items being returned to the State must be disassembled, clean and free of internal wiring. Handhold covers shall be in place, and mast arm bolts shall be attached. The Contractor will not be allowed to "off-load" any items not cleaned or prepared.

b. DR Form 147, "Stock Return for Credit", properly filled in and signed by the Engineer, must accompany the items being returned.

408.04 -- Method of Measurement

Installation and relocation of the various types and sizes of poles, towers, lighting units, and signal structures are measured by the each.

408.05 -- Basis of Payment

1. **Pay Item** — **Pay Unit**

Mast Arm Signal Pole, Type MP _____	Each (ea)
Combination Mast Arm Signal and Lighting Pole, Type CMP _____	Each (ea)
Span Wire Signal Pole, Type SWP _____	Each (ea)
Combination Span Wire Signal and Lighting Pole, Type SWP _____	Each (ea)
Pedestal Pole, Type PP _____	Each (ea)
Signal Structure, Type _____	Each (ea)
Street Lighting Unit, Type SL ____	Each (ea)
High Mast Lighting Unit, Type T _____	Each (ea)
Install Mast Arm Signal Pole, Type MP_____	Each (ea)
Install _____	Each (ea)
Install Combination Mast Arm Signal and Lighting Pole, Type CMP _____	Each (ea)
Install Span Wire Signal Pole, Type SWP _____	Each (ea)
Install Combination Span Wire Signal and Lighting Pole, Type SWP _____	Each (ea)
Install Pedestal Pole, Type PP _____	Each (ea)
Install Street Lighting Unit, Type SL _____	Each (ea)
Relocate High Mast Lighting Unit, Type T _____	Each (ea)
Install High Mast Lighting Unit, Type T _____	Each (ea)
Relocate _____	Each (ea)
Relocate Street Lighting Unit, Type _____	Each (ea)
Install Temporary Lighting Unit, Type _____	Each (ea)

2. Separate payment for pole and tower foundations, if provided, is as described in Section 407.

3. Foundation anchor bolts are subsidiary to the pole and/or tower except for relocated pole and tower foundations.

4. Payment is full compensation for all work prescribed in this Section.

SECTION 409 -- SIGNAL HEADS

409.01 -- Description

The Contractor shall furnish and install signal heads of the type and size shown in the plans. This work shall include furnishing and installing the signal head, lamps, mounting bracket, and backplate (if required). Pole mounted signals do not require backplates.

409.02 -- Material Requirements

1. Traffic and pedestrian signal heads shall be in conformance with Section 1073.

2. Optically programmed signal heads shall be on the NDR Approved Products List.

409.03 -- Construction Methods

1. The Contractor shall install signals plumb, securely attached with all fittings, and so they present a neat appearance.

2. If required, the Contractor shall furnish pipe nipples in appropriate lengths so that all signals on one span will hang at the same elevation.

3. If, after the signal assemblies are erected and the road is open to public travel, the signal system is not put immediately into operation, the signal faces shall be covered with burlap or other opaque material subject to the approval of the Engineer. Inoperative signals on roads open to the public shall always be covered. Tilting the signals upward is not an acceptable alternative to covering the heads.

409.04 -- Method of Measurement

Signal heads shall be measured by the each.

409.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Traffic Signal, Type TS _____	Each (ea)
Pedestrian Signal, Type PS _____	Each (ea)
Install Traffic Signal, Type TS _____	Each (ea)
Install Pedestrian Signal, Type PS _____	Each (ea)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 410 -- DETECTORS

410.01 -- Description

The Contractor shall furnish and install pedestrian pushbuttons and vehicle detectors of the type and size shown in the plans.

410.02 -- Material Requirements

1. Vehicle detectors shall be in conformance with requirements in Section 1073.

2. a. Pedestrian pushbuttons shall be of the type and style specifically intended for this application. They shall be housed in a durable casting and be weathertight. The button and mechanism shall be of sufficient size and rugged design to withstand some abuse and discourage vandalism. The internal switching device shall be closed by physical contact with the buttons.

b. Signs shall be provided for mounting directly above the pedestrian pushbuttons indicating which pedestrian signal is associated with that particular button. These signs shall be of the size, type, and style specifically intended for that purpose. Each sign shall include an arrow to indicate the direction of the crossing to which the button applies.

410.03 -- Construction Methods

1. The Contractor shall install all detectors shown in the plans, including any identified as Department-furnished detectors.

2. The Contractor shall install preformed loop vehicle detectors under new pavement. Saw cut loop detectors shall be installed in existing pavement and shall not be substituted for preformed detectors.

3. The Contractor shall install magnetic detectors for 2-lane approaches under the lane line between lanes. Magnetic detectors installed under 1-lane approaches shall be installed under the outside edge of the lane.

4. a. The Contractor shall exercise care to prevent damage to the wires when installing the loops in the sawed slots in pavement.

b. The slots shall be blown clean of all stones and dirt.

c. The wire shall be tamped as deeply as possible into the slot using a blunt stick.

d. The use of sharp instruments such as screwdrivers, etc., is not allowed.

e. Caution shall be exercised at all corners and sharp bends so as not to damage the insulation or introduce undue stresses in the wire.

f. Testing of the loops during and after installation shall be performed in the manner described by the Engineer.

5. The Contractor shall place preformed loops 1 inch below the surface of the subgrade or base course before paving. Care shall be taken to prevent damage to the loop during the paving operation.

6. A splice between the detector and the lead-in cable shall be made in the pull box nearest the detector. No other splice shall be made in the detector leads.

7. Pedestrian pushbuttons shall be installed as shown in the plans.

410.04 -- Method of Measurement

Vehicle detectors and pedestrian pushbuttons shall be measured by the each.

410.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Vehicle Detector, Type TD _____	Each (ea)
Vehicle Detector, Type ___ Preformed	Each (ea)
Install Vehicle Detector, Type TD _____	Each (ea)
Install Vehicle Detector, Type ____ Preformed	Each (ea)
Pedestrian Pushbutton, Type PPB	Each (ea)
Install Pedestrian Pushbutton	Each (ea)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 411 -- TRAFFIC SIGNAL CONTROLLER

411.01 -- Description

1. The Contractor shall furnish and install traffic signal controllers of the type and at the locations shown in the plans. The Contractor shall take care that all conduits within the cabinet are clear of any braces or equipment which would interfere with cable runs. One spare 2 inch conduit bend shall be installed in each pad mounted controller foundation. The ends of the bend shall be capped. This work shall include furnishing and installing the controller, concrete, spare bend, and all excavation, backfilling, labor, equipment, tools, and incidentals required to complete the work.

2. All equipment required to be installed on the power pole, such as meter sockets and breaker boxes is considered subsidiary to the traffic signal controller installation.

411.02 -- Material Requirements

1. Traffic signal controllers shall meet the requirements in Section 1073.

2. Concrete shall meet the requirements in Section 1002.

411.03 -- Construction Methods

The controller shall be placed on a concrete pad as shown in the plans. The controller shall not be placed in a ditch or depression that is subject to water ponding or flooding. Pole mounted controllers shall have a pad constructed below the controller as shown in the plans.

411.04 -- Method of Measurement

Traffic signal controllers shall be measured by the each.

411.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Traffic Signal Controller, Type TC _____	Each (ea)
Install Traffic Signal Controller, Type TC _____	Each (ea)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 412 -- LUMINAIRES

412.01 -- Description

The Contractor shall furnish and install luminaires of the size and type indicated in the plans.

412.02 -- Material Requirements

Luminaires shall conform to the requirements in Section 1073.

412.03 -- Construction Methods

1. The Contractor shall install luminaires in conformance with the manufacturer's recommendations.

2. Conventional Luminaires:

a. Unless indicated otherwise, luminaires shall be installed perpendicular to the centerline of the roadway being lighted.

b. The position of the lamp socket in each luminaire must be adjusted in accordance with the manufacturer's specifications to meet the photometric requirements shown in the plans.

c. Unless otherwise indicated in the plans or directed by the Engineer, luminaires will be installed level in both horizontal axes.

d. Each luminaire shall be fused. Fuses shall be installed in each hot leg using approved disconnect type in-line fuseholders. Fuseholders shall be located in the transformer base or the base of the pole.

e. The month and year of installation shall be permanently indicated on the base of each lamp at the location provided by the manufacturer.

3. High Mast Luminaires:

a. Luminaires shall be adjusted to proper alignment and orientation with respect to the roadway as shown in the plans.

b. All connections from the portable cable to the individual ballasts shall be made in the junction box located on the luminaire support assembly. When an electrical cable passes through any metal or pulley, a bushing shall be provided.

c. Each luminaire shall be fused by installing an in-line fuseholder in each hot leg. Fuseholders shall be located inside the luminaire.

d. Night inspection by the Engineer may determine the need for adjustments to the luminaires.

e. When shielding is required, shielding methods proposed must be approved by the NDR Lighting Engineer before any materials are installed. Unless indicated otherwise, external shields will not be allowed.

4. Wall Mounted/Underdeck/Overhead Luminaires:

a. Wall mounted/underdeck/overhead luminaires shall be installed as shown in the plans. Each luminaire shall be grounded.

b. Fuses shall be installed in each hot leg using approved in-line fuseholders located inside the units or in a junction box when so indicated in the plans.

c. Wall mounted/underdeck/overhead luminaires shall be adjusted for optimum light distribution as directed by the Engineer.

5. Sign Lighting Luminaires:

a. The sign lighting luminaires shall be mounted as shown in the plans and in accordance with the manufacturer's instructions.

b. The lamps shall be 150 watt high pressure sodium or as shown in the plans.

c. All conductors shall be copper and shall be installed in conduit.

d. The feeder cable shall be a minimum No. 8 gauge diameter THWN with a 30 ampere circuit breaker at the service entrance.

e. Each sign structure shall be controlled by a 15 ampere, 2 pole NEMA 3R breaker at a location convenient for luminaire maintenance.

f. Each sign structure shall have a photoelectric control mounted near the sign unless the sign luminaires are tied into the roadway lighting photocells.

g. The relays for switching the line current to the lighting fixtures shall be mounted near the circuit breaker or as directed by the Engineer.

6. Luminaire Conversion:

a. The Contractor shall install new luminaires with lamps on existing poles as indicated in the plans. The Contractor shall provide new internal pole and mast arm wiring with in-line fuseholders and fuses.

b. The existing luminaires will become the property of the Contractor and shall be removed from the project site.

c. The position of the lamp socket in each luminaire must be adjusted in accordance with the manufacturer's specifications to meet the photometric requirements shown in the plans.

d. Unless otherwise indicated in the plans or directed by the Engineer, luminaires will be installed level in both horizontal axes.

e. The month and year of installation shall be permanently indicated on the base of each lamp.

412.04 -- Method of Measurement

Luminaires, luminaire conversions, and wall mounted/underdeck/overhead luminaires shall be measured by the each.

412.05 -- Basis of Payment

1. **Pay Item** **Pay Unit**

Luminaire, Type _____	Each (ea)
Underdeck Luminaire, Type _____	Each (ea)
Luminaire Conversion, Type _____	Each (ea)
High Mast Luminaire, Type _____	Each (ea)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 413 -- LIGHTING CONTROL CENTERS

413.01 -- Description

1. New Lighting Control Center:

The Contractor shall furnish and install a new lighting control center of the size and type shown in the plans. This work includes the relay, disconnect, contactor, pole, control cabinets, grounding devices, photo control, conduit, concrete, fittings, excavating, backfilling, compacting, and all other items required for a complete installation.

2. Relocate Existing Control Center:

The Contractor shall relocate the lighting control center as shown in the plans. The lighting control center shall be carefully dismantled, stored, and protected from damage. The Engineer may designate specific areas for temporary storage of the materials. The lighting control center shall be installed at the prescribed new location and connected electrically as shown in the plans. Missing or damaged components shall be replaced by the Contractor before final payment will be made.

3. Temporary Lighting Control Center:

The Contractor shall install the temporary lighting control center as prescribed in the plans.

4. a. If the Department is furnishing the lighting control center, the items and the location where they are to be picked up will be shown in the plans. The Contractor shall provide all other materials required for a complete installation and shall install all materials as shown in the plans.

b. The Contractor shall contact the Engineer for additional details associated with obtaining the Department-furnished material. The Engineer will supply the Contractor with a completed DR Form 146, "Stock Requisition." The Contractor will not be issued materials without a properly completed "Stock Requisition."

413.02 -- Material Requirements

Lighting control centers shall conform to the requirements shown in the plans and Section 1073.

413.03 -- Construction Methods

1. The location of the lighting control center is approximate. The actual location will be determined by the electric utility and the Engineer.

2. The Contractor shall assemble the lighting control center in accordance with the manufacturer's instructions and the details shown in the plans or as directed by the Engineer.

3. The Contractor shall take appropriate action to insure that all conduits within cabinets are clear of any braces or equipment which would interfere with cable runs. Unless indicated otherwise, one extra 1 1/2 inch conduit bend, with the ends capped, shall be installed in each pad mounted lighting control center cabinet foundation.

413.04 -- Method of Measurement

Lighting control centers shall be measured by the each.

413.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Lighting Control Center, Type _____	Each (ea)
Install Lighting Control Center, Type _____	Each (ea)
Relocate Lighting Control Center, Type _____	Each (ea)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 414 -- HIGH MAST LOWERING SYSTEMS

414.01 -- Description

The Contractor shall furnish and install a new high mast lowering system on a new or existing tower as indicated in the plans. This work shall include a headframe, headframe cover, luminaire support ring, bracket arms, hoist winch and winch cables, hoist cables, internal power unit, and all labor, equipment, tools, and incidentals necessary to complete the work.

414.02 -- Material Requirements

High mast lowering systems shall be on the NDR Approved Products List.

414.03 -- Construction Methods

1. The Contractor shall install the new high mast lowering system on a new or existing tower in accordance with the manufacturer's instructions and recommendations.

2. Installation of a new high mast tower lowering system may require some modification to the tower. Modifications shall be made as detailed in the plans or as directed by the Engineer.

3. The installation of an approved lowering system shall be under the direct supervision of a qualified representative of the manufacturer. The manufacturer's representative shall be on site to advise the Contractor during the installation of at least one complete assembly. Duties of the manufacturer's representative shall include, but not be limited to, the following:

a. Directing all adjustment to the lowering system to insure positive latching and unlatching. This will consist of a minimum of 3 complete raising and lowering cycles without malfunction.

b. Educating the maintaining utility and/or NDR personnel in the methods of proper maintenance to avoid lowering system malfunctions together with the proper procedures to follow in the event of a malfunction.

414.04 -- Method of Measurement

High mast lowering systems, furnished and installed on existing high mast towers, will be measured by the each.

414.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
High Mast Lowering System, Type _____	Each (ea)

2. A high mast lowering system furnished by the Contractor and installed on a new tower will not be paid for directly, but will be considered subsidiary to the new high mast tower.

3. Payment is full compensation for all work prescribed in this Section.

SECTION 415 -- PROJECT LIGHTING SYSTEM MAINTENANCE

415.01 -- Description

1. "Project Lighting System," when used in this Section, shall be taken to mean all the lighting units and their associated circuitry (conduit, cable, and controls) located within the limits of the project. A lighting unit is a pole, luminaire, and, usually, a mast arm and breakaway device. Occasionally included are, tennon top and anchor base units.

2. The Contractor will be responsible for the proper operation and maintenance of all lighting units on the project (existing, relocated, temporary, and/or new) from the time the project begins until construction is complete and the project is accepted.

3. The Contractor will be totally responsible for any damage caused by his/her forces to any existing equipment like lighting units, pull boxes, controls, or conduit and cable. Any damage shall be repaired within 24 hours. The Contractor shall supply all needed materials. If any disruption to circuits or other components causes the lighting to fail, the Contractor shall install temporary conductors as required and make the necessary repairs to return the system to operation at no additional cost to the Department.

415.02 -- Material Requirements

1. Replacement parts, except as noted in Subsection 415.03, shall be furnished by the Contractor and must be compatible with the lighting system.

2. Lamps provided must be on the NDR Approved Products List.

415.03 -- Construction Methods

1. a. Replacement parts for new lighting units (units being installed under the present contract) shall be furnished by the Contractor.

b. Replacement parts (poles, mast arms, breakaway bases, power foundations, and luminaires) for existing, relocated, and temporary lighting systems will be available at the Department's storage area in Lincoln.

2. Lamps for all units will be supplied by the Contractor.

3. If for any reason a lighting unit fails or is damaged, it shall be repaired or replaced and put back in working order within 24 hours from the time of failure or damage.

415.04 -- Method of Measurement

Project lighting system maintenance is measured by the each per day the entire system is in operation.

415.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Project Lighting System Maintenance	Day (d)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 416 -- TEMPORARY LIGHTING SYSTEMS

416.01 -- Description

1. Temporary lighting systems are used to provide illumination on temporary traffic ways such as detours, fly-by lanes, and traffic crossover lanes through and/or around zones of construction.

2. The Contractor shall install the temporary lighting systems as prescribed in the plans. The plans shall indicate whether poles, luminaires, lamps, photo controls, power foundations, and breakaway bases are to be Department or Contractor-furnished.

3. The Contractor shall operate and maintain the lights daily from dusk to dawn throughout the construction period. The Contractor will be responsible for the proper operation and maintenance of the temporary lighting system. Any failure or malfunction of the system shall be promptly corrected by dusk of the following day.

416.02 -- Material Requirements

1. a. The poles, luminaires, lamps, photo control, power foundations, and breakaway bases will be furnished by the Department or the Contractor as indicated in the plans.

b. All other lighting materials such as replacement lamps, connector cables, fittings, and splice kits are to be furnished by the Contractor.

c. The Contractor shall obtain the State-furnished materials from the NDR's storage area at Lincoln, Nebraska. The Contractor will be responsible for transporting the material from the NDR storage area to the job site.

2. Contractor-furnished lighting units and all other items required for a complete system shall conform to the requirements in the plans and specifications.

3. On Contractor-furnished systems, additional poles, luminaires, and breakaway devices shall be retained in the Contractor's stock for replacement purposes. Upon completion of the project, the Department will, if the Contractor desires, accept the surplus lighting units (up to 3 each poles, luminaires, and breakaway devices) as prescribed in Subsection 109.06.

4. In the event of damage to or failure of a lighting unit on a Department-furnished system, the Department will provide additional lighting units for replacement by the Contractor.

5. a. When the temporary lighting units are no longer required, the Contractor will carefully dismantle, clean, and return the salvaged material to the Department's storage area indicated in the plans. All components not ordered salvaged will become the property of the Contractor and removed from the project.

b. The Contractor shall notify the NDR storage area superintendent 2 days before delivery of the materials to the storage area. Upon delivery, the materials shall be placed in the storage area at the location(s) designated by the storage area supervisor.

6. When the units are returned:

a. All luminaires are to have the photo control removed and the photo control receptacle and the luminaire mounting hole covered with duct tape. Photo controls will become the property of the Contractor.

b. All poles shall have handhold covers fastened securely in place.

c. Power foundations and transformer bases shall have all associated bolts, nuts, and washers attached. Breakaway support couplings are to be bundled in sets of 4 held together with duct tape with all bolts, nuts, and washers fastened in place on the couplings.

7. a. The plans shall indicate whether the Contractor or the Department arranges and pays for electrical power.

b. If the Contractor is required to arrange and pay for the electrical power to the temporary lighting system, the source of power may be an electric utility serving the area, if such a source is available, or it may be an engine-generator furnished, operated, and maintained by the Contractor. The power source must be a dependable, well regulated source of power adequate for the requirements of the lighting system.

c. Where power to the temporary lighting system is arrranged for by the Department, the Contractor will not be responsible for the cost of the electrical energy required for the operation of the temporary lighting.

416.03 -- Construction Methods

1. The Contractor shall install, test, and operate the temporary lighting system before traffic is routed through the construction zone. The Contractor shall also maintain and operate the system until the project is complete.

2. The Contractor shall be responsible for providing the electrical power and connecting it to the lighting system.

3. It will be the Contractor's responsibility to protect the poles, luminaires, and the foundations from damage during installation, removal, salvage, storage, and transportation to and from the storage area. All items must be accounted for and in good working condition. Missing or damaged components must be replaced by the Contractor at no additional cost to the Department.

416.04 -- Method of Measurement

1. a. Installation of Contractor and Department-furnished temporary lighting systems shall be measured by the each.

b. When the bid proposal's Schedule of Items contains the pay item "Temporary Lighting System, Type _____", then the Contractor is required to furnish the temporary lighting system.

c. When the bid proposal's Schedule of Items contains the pay item "Install Temporary Lighting System, Type _____", the temporary lighting system components are provided by the Department.

2. Operation and maintenance of the temporary lighting systems shall be measured by the number of calendar days each temporary lighting system is in operation.

416.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Temporary Lighting System, Type ____	Each (ea)
Install Temporary Lighting System, Type _____	Each (ea)
Operation and Maintenance of Temporary Lighting System, Type ____	Day (d)

2. Payment shall be made according to the following schedule: Two-thirds of the contract unit price will be paid when the system is installed, in place, and approved by the Engineer; one-third of the contract unit price will be paid when the system is removed, delivered to the Department, and accepted by the Engineer.

3. Payment is full compensation for all work prescribed in this Section.

SECTION 417 -- HIGHWAY SIGNS

417.01 -- Description

This work shall consist of all materials and labor necessary to provide, fabricate, and install highway signs at the locations shown in the plans.

417.02 -- Material Requirements

1. Materials for highway signs shall conform to the requirements of Section 1070 and the *Manual on Uniform Traffic Control Devices for Streets and Highways*.

a. "Type A Signs" are regulatory, warning, guide, and information signs composed of a flat aluminum sheet background surfaced with reflective sheeting and the message either directly applied or reverse screened on the sign face, all in the colors specified in the plans. Bridge and hazard markers shall be classified as a Type A sign.

b. "Type B Signs" are large guide and information signs mounted along the roadside or on overhead structures and constructed of molded extruded panels or reinforced aluminum, horizontally joined panels having a reflectorized background and direct applied letters, numerals, symbols, and border.

2. a. "Type A Signs" shall be mounted on breakaway posts made from aluminum, steel, or wood as indicated in the plans.

b. Type B ground mounted signs are to be mounted along the roadside as shown in the plans and supported by structural steel beam breakaway posts with the post stub extending into round, reinforced concrete footings.

c. Type B overhead signs are to be mounted over the roadway on sign structures, including cantilever structures, with vertical supports installed on reinforced concrete foundations or on sign brackets attached to existing roadway bridges.

3. Letters, numerals, symbols, and the border for "Type B Signs" shall be reflective materials meeting the requirements of Type III direct applied or detachable copy in AASHTO M 268.

4. Reflective background sheeting for all signs shall meet the requirements of AASHTO M 268 Type III.

5. All concrete shall be Class 47B-2,900 conforming to the requirements of Section 1002.

417.03 -- Construction Methods

1. The Contractor shall prepare the sheet aluminum for reflective sheeting on both Type A and B signs as follows:

a. Paint shall be removed with lacquer thinner or a controlled alkaline cleaning system.

b. The aluminum sheet and extrusheet panels shall be degreased by one of the following methods:

(1) Vapor Degreasing--Total immersion of the sign in a saturated vapor of trichlorethylene or perchlorethylene.

(2) Alkaline Degreasing--Signs shall be immersed in a tank containing alkaline solutions, controlled and titrated to the solution manufacturer's specifications. Immersion time shall depend upon the amount of soil present. Metal shall be rinsed thoroughly with running water.

c. (1) The aluminum sheet and extrusheet panels shall be acid etched in a 6 to 8 percent proprietary, phosphoric acid etching solution at 100°F.

(2) After etching, the metal shall be throughly rinsed with running cold water.

(3) The cold rinse shall be followed by a hot water rinse. A forced hot air drier shall be used to dry the panels.

(4) Metal shall not be handled directly, but shall be moved with a mechanical device or clean canvas gloves between all cleaning and etching operations and the application of reflective sheeting.

(5) There shall be no opportunity for metal to contact greases, oils, or other contaminants before the application of reflective sheeting.

2. a. (1) The Contractor shall apply the reflective sheeting without visible seams or joints.

(2) If seams are required, they must be carefully matched for color at the time of sign fabrication to provide uniform appearance and brilliance, both day and night.

(3) Signs on which the background color of adjacent sheets or panels is not properly matched will be rejected.

b. Reflective sheeting shall be mechanically applied to properly treated base panels using the sheeting manufacturer's recommended procedures and equipment.

c. After aging 48 hours at 75°F, adhesion of reflective sheeting to the sign surface shall be strong enough to resist stripping from the panel when tested with a stiff putty knife.

3. The message, legend, and border of Type A signs shall be applied by one of two processes, depending on the kind of sign.

a. (1) Direct screened processing shall consist of processing the message, legend, and border color on the face of the sign by the silk screen process.

(2) The color material to be used and the dry film thickness to be obtained shall be as recommended by the manufacturer of the reflective sheeting.

(3) The color of the sign face, message, legend, and border shall be as shown in the plans.

b. (1) Reverse screen processing shall consist of processing an opaque or transparent color over the sign face to form the legend and border.

(2) The opaque or transparent process color material to be used and the dry film thickness to be obtained shall be as recommended by the manufacturer of the reflective sheeting.

(3) The color of the sign face, legend, and border shall be as shown in the plans.

4. a. The extrusheet panels for each sign shall be of the length and width specified in the plans.

b. The width of the top, intermediate, and bottom panels shall be in the sequence shown in the plans for each sign.

c. There shall be no longitudinal gap between panel joints on the sign face, and the face of the panels shall be in the same plane on the sign face.

d. The ends of all panels in any one sign shall be perpendicular and in line. The ends shall be free from burrs.

e. The surface of all sign panels shall be flat and free of flaws.

f. The sign shall be attached to 4 inch aluminum H-beam vertical supports as shown in the plans.

g. The vertical supports shall be flush with the top of the sign.

5. a. (1) Letters, numerals, symbols, and border for Type B signs shall be directly applied.

(2) Large letters, numerals, and symbols may be fastened to the panel face with self-plugging type rivets, 1/8 inch in diameter and of all aluminum construction, when they cannot be directly applied.

b. Rivet length shall be as recommended by the manufacturer for the combined thickness of each legend material and the structural panels to which they are applied.

c. After a rivet is set, the stem, if remaining, shall be trimmed flush with the rivet head in a manner recommended by the rivet manufacturer.

6. Height of all signs shall be as shown in the plans.

7. a. The Engineer will establish by stake (or mark on the pavement) the location of each sign and will also establish the elevation of the edge of the roadway if it does not exist.

b. (1) All roadside signs on the freeway roadway, including gore signs, shall be mounted so that any edge of the sign which is adjacent to a roadway will be 2 feet outside of the curb where there is a barrier type curb.

(2) On rural freeways (interstate), the edge of any sign shall be at least 35 feet from the edge of the roadway.

(3) On rural expressways, the edge of any sign shall be at least 30 feet from the edge of the roadway.

(4) On urban freeways or expressways, the edge of any sign shall be at least 30 feet from the edge of the roadway.

8. a. Type B signs shall be erected so that the sign face is vertical and positioned as shown in the plans. On curved alignments, the angle of placement should be determined by the course of approaching traffic rather than by the roadway edge at the point where the sign is located.

b. Type B signs shall be fastened to the supports in accordance with the recommendations of the extrusheet panel manufacturer. All supports shall be cut off flush with the top of the sign.

c. Type A signs shall be fastened to sign posts with threaded bolts as prescribed in Section 1071.

9. a. The Contractor shall drill wood posts as shown in the plans to provide a breakaway feature.

b. (1) The Contractor shall fabricate steel beam breakaway posts in accordance with Section 708.

(2) Mill test reports shall be submitted to the Engineer before fabrication.

(3) The saw cut for the breakaway hinge should be made on the job site to avoid deformation of the pre-cut post in shipping.

(4) The saw cut shall be free of galvanizing material.

(5) The saw cut and any damage to galvanizing shall be repaired in accordance with Method 2 of Section 1061.

(6) Any deformation of the post shall be cause for rejecting the post.

10. The fuse plate bolt shall be tightened by the turn-of-the-nut method prescribed in Subsection 708.03. The base connection assembly shall follow the procedure outlined in the plans which shall include rechecking the torques until all bolts in the base have the prescribed torque. This procedure shall be repeated immediately preceding the final inspection of the project.

11. a. Footings for roadside mounted signs on steel beam breakaway posts shall be concrete.

b. The footing shall be circular in shape and of the diameter and depth shown in the plans.

c. Before placing concrete footings, stub posts shall be placed so the posts are plumb and correctly spaced.

d. Footings shall be no higher than 4 inches above the ground to prevent snagging.

e. Footing construction shall be in accordance with the applicable requirements of Sections 702, 704, and 707.

12. When 2 or more signs are required on an overhead sign support, the bottom of all signs shall have the same elevation so they will be horizontally aligned with each other. All signs shall be hung at a minimum of 2 feet above the walkway. Sign posts and vertical supports used as sign stiffeners shall be cut off flush with the top of the sign.

417.04 -- Method of Measurement

1. Providing, fabricating, and installing Types A and B signs shall be measured by the square yard.

2. Providing and installing breakaway steel supports for Type A and Type B signs shall be measured by the pound of unplated, unwelded, and undrilled steel. The pounds of steel shall be the weight per foot multiplied by the length of sign support above the stub post required at each location. Connection shall be subsidiary to this item.

3. Providing, fabricating, and installing wood supports for Type A and Type B signs shall be measured for payment by the linear foot. The quantity to be paid for shall be the actual support length used or as ordered by the Engineer.

4. Providing and constructing concrete footings for a steel beam breakaway post for Type A and B signs will be measured by the each for each post.

417.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Type A Sign	Square Yard (SY)
Type B Sign	Square Yard (SY)
Install Type A Sign	Square Yard (SY)
Install Type B Sign	Square Yard (SY)
Structural Steel for Sign Supports	Pound (lb)
4 x 4 Inch Wood Sign Support	Linear Foot (LF)
4 x 6 Inch Wood Sign Support	Linear Foot (LF)
_____ Sign Support Footing	Each (ea)

2. Furnishing and installing 40 inch long stub posts and the required reinforcing steel shall be subsidiary to the "_____ Sign Support Footing".

3. Connecting and mounting hardware is subsidiary to the relevant pay item.

4. Payment is full compensation for all work prescribed in this Section.

SECTION 418 -- OVERHEAD SIGN SUPPORTS

418.01 -- Description

1. a. "Overhead Sign Support, Location _____" shall consist of:

(1) Providing all materials to construct overhead sign supports.

(2) Transporting all sign support materials to the project site.

(3) Constructing all trusses and other sign support structures as shown in the plans (including attachment of sign brackets to the structure).

(4) Providing the Department copies of the manufacturer's designs of the overhead sign support structure and the reinforced concrete foundations for all sign support structures. Steel cantilever and steel truss or aluminum box truss structures shall be manufacturer-designed. Bridge brackets shall comply with the design provided in the project plans.

b. Aluminum or steel trusses that span multi-lane roadways shall be provided with a sign lighting system in accordance with Sections 401 through 412.

c. Steel cantilevers shall be installed at the side of the roadway with the horizontal member overhanging the roadway and shoulder.

d. Steel sign brackets shall be attached to existing roadway bridges spanning the roadway and shall be provided with a sign lighting system in accordance with Sections 401 through 412.

e. Plans shall be augmented by Contractor-furnished working drawings submitted in accordance with Subsection 105.02.

2. Full Span and Cantilever Sign Structures:

a. The overhead sign supports shall be steel or aluminum box or single panel truss structures.

b. The work shall consist of designing, furnishing, and erecting a structure, complete with vertical end supports, span members, walkways, sign brackets, foundations, and all necessary material and fasteners for assembling the structures. All material fabrications shall be in accordance with the applicable requirements of Sections 401 through 412, 417, 708, and 1040.

c. All overhead sign support structures shall be fabricated in a plant owned and operated by a fabricator sufficiently experienced to manufacture the structures in accordance with these *Specifications*. The Contractor shall furnish the name and address of the fabricator, if requested by the Engineer, and evidence of the fabricator's qualifications and experience.

418.02 -- Material Requirements

1. Aluminum cantilevers, trusses, and other sign supports shall be made from the alloys in Table 418.01 and shall conform to the indicated ASTM requirements.

2. Steel sign supports for Type B (See Section 417 for type definitions) signs shall be fabricated from structural steel conforming to the requirements of ASTM A 36/A 36M with a maximum working stress of 20,000 psi (140 MPa). After fabrication, the cantilever members shall be galvanized in accordance with ASTM A 123.

Table 418.01
Alloy Requirements

Member or Shape	Aluminum Alloy	ASTM Requirements
Extruded tubes for chord and column members	6061-T6	B211/B 211M; B 429
Bracing Members	6063-T6	B221/B 221M; B 429
Extruded Shapes	6061-T6	B211/B 221M; B 308/B 308M
Plates	6061-T6	B209/B 209M
Post Base and Chord Flange	356.0-T6	
Aluminum Alloy Sand Castings	356.0-T6	B26/B26M
Aluminum Alloy Permanent Mold Castings	356.0-T6	B 108
Grates	6061-T6	B211/B 211M;
		B221/B221M
Bearing Bars	6061-T6	B211/B 211M;
		B221/B221M
Cross or Crimp Bars	6063-T5	B211/B 211M;
		B221/B221M
Pipe Handrail	6061-T6/6063-T6	B 221M; B 241/B 241M
Post and Chord Caps	356.0-F	B 26/B 26M
Anchor Bolts & Nuts	---	A 325
Galvanizing	---	A 153

3. Steel sign brackets to be attached to existing bridges shall be fabricated from structural steel conforming to ASTM A 36/A 36M with a maximum working stress of 20,000 psi (140 MPa).

4. a. The reinforced concrete foundations shall be constructed to the dimensions shown in the shop plans.

b. The materials and construction methods shall be in accordance with the applicable requirements of Sections 702, 704, and 707 and as required in the shop plans.

c. Anchor bolts of the specified size for each support shall be supplied in a welded assembly by the manufacturer to ensure proper bolt spacings and alignment. This assembly shall be detailed on the shop plans. The anchor assembly cage shall be placed at the depth shown in the shop plans, properly aligned and secured in place before placing concrete. Once the concrete has set, **no** adjustments or realignments shall be made to the anchor bolts. Field straightening of anchor bolts will not be permitted. The bolts shall be truly vertical, with no more than a 1/8” deviation in 12” (3 mm in 300 mm) of length permitted. All cantilever sign structures shall use a **minimum** of 6, 2-inch (50 mm) diameter bolts.

d. A two-inch diameter non-metallic electrical conduit shall be installed in each foundation as shown in the plans, with caps on both ends to keep the conduit clean until wiring is installed.

5. Anchor Bolts for Cantilever Sign Supports:

a. The structure manufacturer shall design and furnish the anchor bolts in accordance with AASHTO M314 and designed for fatigue. A bolt sample (including nuts and washers) from each heat of steel used on the project (or multiple projects) shall be submitted to the Materials and Research Division for destructive testing. Threads on anchor bolts shall be rolled in accordance with standard industry practice, the use of cut threads shall not be permitted. The top 12 inches (300 mm) of the anchor bolt shall be cleaned and painted with zinc rich paint prior to shipment with a minimum dry film thickness of 4 mils (100 μm). The type of paint and the method of application shall be as approved by the Materials and Research Division. After installation the Contractor shall touch-up paint threads using approved methods.

b. The heavy hex nuts shall meet the requirements of ASTM A 563, Grade C3 or DH3.

c. The hardened steel washers shall conform to the requirements of ASTM F 436 or ASTM F 436M. The plate washer shall conform to the requirements of ASTM A 36/A 36M. Only flat washers shall be used, the use of lock washers shall not be permitted. The manufacturer of the anchor bolts shall furnish certification and test reports covering the steel used.

d. The manufacturer of the anchor bolts shall furnish certification and test reports covering the steel used. The test report shall show the following:

(1) Chemical analysis of the steel used.

(2) Yield strength in pounds per square inch (MPa).

(3) Tensile strength in pounds per square inch (MPa).

(4) Percent elongation in 2 inches (50 mm).

(5) Percent reduction in area.

6. Full Span and Cantilever Sign Design Requirements:

a. (1) The overhead span and cantilever sign structures shall be box or single panel trusses designed in accordance with the latest edition of the *Specifications for the Design and Construction of Structural Supports for Highway Signs*, published by the American Association of State Highway Transportation Officials.

(2) The design wind velocity used for structure calculations shall be 85 mph (137 kph) with a 1.3 gust factor.

(3) The sign spans, sign locations, and sign mounting heights used for structure calculations shall be as shown in the plans.

(4) The design areas used for calculations shall be the sign areas shown plus 30 percent or as noted on the plans.

b. (1) Designs, materials, and basic member shape, once selected, shall be used throughout the project.

(2) Overhead Truss Structures shall be aluminum or steel galvanized after fabrication. Cantilever Structures shall be of galvanized steel.

(3) All overhead structures shall be designed to be supported by single poles or end frames having no more than 2 vertical main members of a closed cross section.

c. Footings shall be reinforced concrete with the overhead portion of the structure attached by means of base plates and anchor bolts. The top of each footing shall extend 12 inches (300 mm) above ground level and shall have a 1-inch (25 mm) chamfer on its edges. Footings shall be constructed so that the top surface shall be level [less than ¼" out in 3 feet] (6 mm in 90 mm).

d. Footings shall be designed from soil boring test results obtained from the Engineer or shown in the plans.

e. The bottom of aluminum supporting shafts and all anchor bolts shall receive a heavy coating of aluminum filled, resilient sealing compound completely covering all areas which may contact the concrete. The sealing compound shall be on the *NDR Approved Products List*.

f. Corrosion of aluminum caused by contact with dissimilar metals shall be prevented by proper design considerations and installation procedures.

g. (1) The structure shall be lighted with walkways provided in front of and in back of the entire length of the signs.

(2) The walkways shall be continuous to the vertical access point/support.

(3) Walkways shall have a railing along the front side which can be folded when not in use. The fold-down handrails shall be limited to sections that are 12 feet (4 m) or less in length.

(4) No part of a walkway or railing in the folded position shall obstruct normal viewing of the sign.

(5) The cantilever structures shall be lighted and have front and back walkways, continuous over the width of the sign and shoulder and extending to the vertical end support. These walkways shall be at the same level +/- 6 inches (150 mm).

(6) Both front and back walkways (closest to cantilever arm) shall extend a minimum of 2 feet (600 mm) beyond the sign's vertical edge.

(7) Vertical deflection of the cantilever arm shall be limited to L/120.

h. For access to the walkway, a ladder or other type of foot support shall be constructed on the end support beginning 9 feet (3 m) above the ground.

i. Sign lighting and electrical equipment for the structure shall be in accordance with the applicable requirements of Sections 401 to 413 and 1073.

j. The manufacturer shall specify on the shop plans their recommendations as to how the upright shall be installed on the foundation and the nuts tightened. Recommendations will include the method of tightening all nuts for the installation and assembly of the structure (turn of the nut, torque, nut rotation, etc.).

k. Before fabrication, the Contractor shall prepare and submit complete design drawings, calculations, and other supporting data for approval. These shall include 6 sets of prints and drawings on standard size plan sheets (36 x 22 inches [910 x 560 mm]) and 2 sets of design computations prepared and signed by a registered Professional Engineer licensed in Nebraska.

418.03 -- Construction Methods

1. General:

a. The Contractor shall take precautions to avoid scarring or marring aluminum or galvanized surfaces. Any such damage which, in the judgment of the Engineer, gives an objectionable appearance or contributes to weakening of the structure will be cause for rejection.

b. The Contractor shall remove all casting irregularities from cast parts.

c. Tubing shall be seamless; and exterior and interior surfaces shall be clean, smooth, and free from slivers, lamination, grooves, cracks, or other defects.

d. Poor welding skill, as noted by visual inspection, will be sufficient cause for rejection.

2. Fabrication of Sign Structures:

a. Aluminum alloy fabrication shall conform to AWS procedures and the following:

(1) Thermal cutting will not be allowed.

(2) Material 1/2 inch (12.5 mm) or less in thickness may be sheared, sawed, or milled. Material over 1/2 inch (12.5 mm) in thickness shall be sawed or milled. Cut edges shall be true and free from excessive burrs or ragged breaks.

(3) Material to be bent may be heated to a temperature not exceeding 400°F (205°C) for a period not exceeding 15 minutes to facilitate bending.

(4) Bolt holes shall be drilled full size or subpunched 1/8 inch (3 mm) smaller than the nominal diameter of the fastener and reamed to size. Unless otherwise indicated in the plans, the finished diameter of the holes shall be not more than 7 percent greater than the nominal diameter of the fastener.

(5) The length of the vertical end frames for structures shall be field checked before fabrication.

b. Fabrication of steel materials (center mounts, cantilevers, and sign brackets) shall be in accordance with the applicable requirements of Section 708. Center mount and cantilever structures shall be galvanized as required by the plans. Sign brackets shall be painted in accordance with the applicable requirements of Section 709 and as required by the plans.

3. Aluminum Welding Requirements:

a. (1) The aluminum alloys shall be welded in accordance with the ASTM requirements listed below:

Wrought heat-treatable alloys
Alloy 6061
Alloy 6063
Cast heat-treatable alloy
Alloy 356.0

(2) Material used for permanent backing shall be at least equivalent in weldability to the base metal being welded.

(3) These *Specifications* include provisions for welding by the gas metal-arc process and the gas tungsten-arc process.

(4) Bare wire electrodes for use with the gas metal-arc process and welding rods for use with the gas tungsten-arc process shall conform to

the requirements of *Specifications for Aluminum and Aluminum-Alloy Welding Rods and Bare Electrodes, AWS* A5.10.

(5) Tungsten for the gas tungsten-arc process shall conform to the requirements of *Specifications for Tungsten-Arc Welding Electrodes*, AWS A5.12. Filler metals to be used with particular base metals shall be as shown in Table 418.02. Other filler metals may be used as approved by the Engineer.

Table 418.02
Filler Metal Requirements

AWS Base Metal	Use Filler Metal
6061 welded to 6063	ER5356
6063 welded to 6063	ER5356
356.0 welded to 6061	ER4043
356.0 welded to 6063	ER4043

(6) (i) Filler metals shall be kept covered and stored in a dry place at relatively uniform temperatures.

(ii) Original rod or wire containers shall not be opened until time to be used.

(iii) Rod and wire shall be free of moisture, lubricant, or other contaminants.

(iv) Spools of wire temporarily left unused on the welding machine shall be kept covered to avoid dirt and grease contamination.

(v) If a spool of wire is to be unused for more than a short length of time, it shall be returned to the carton and the carton tightly resealed.

(7) (i) Shielding gases shall be welding grade or better. Shielding gas for gas metal-arc shall be argon, helium, or a mixture of the two (approximately 75 percent helium and 25 percent argon).

(ii) Shielding gas for gas tungsten-arc welding done with alternating current shall be argon.

(iii) Shielding gas for gas tungsten-arc welding done with direct current, straight polarity, shall be helium.

(iv) Hose used for shielding gases shall be made of synthetic rubber or plastic.

(v) Natural rubber hose shall not be used. Hose which has been previously used for acetylene or other gases shall not be used.

b. (1) (i) Joint details shall be in accordance with design requirements and detail drawings.

(ii) The location of joints shall not be changed without the approval of the Engineer.

(iii) Edge preparation shall be by sawing, machining, clipping, or shearing. Gas tungsten-arc or gas metal-arc cutting may also be used.

(iv) Cut surfaces shall meet the American Standards Association surface roughness rating value of 1,000.

(v) Oxygen fins, tears, and other defects which would adversely affect the quality of the weld will not be allowed.

(vi) Dirt, grease, lubricants, or any organic materials shall be removed from the areas to be welded by cleaning with a suitable solvent or by vapor degreasing.

(vii) On all edges and surfaces to be welded, the oxide shall be removed just before welding by wire brushing or by other mechanical methods such as rubbing with steel wool or abrasive cloth scraping, filing, rotary planing, or sanding. If a wire brush is used, the brush shall be made of stainless steel.

(2) Hand or power driven wire brushes which have been used on other materials shall not be used on aluminum.

(3) (i) Where mechanical methods of oxide removal are found to be inadequate, a standard chemical method shall be used.

(ii) Chemical removal of aluminum oxide shall be accomplished by one of the chemical treatments recommended in the AWS or the Aluminum Association *Welding Aluminum* pamphlet.

(iii) Welding shall be done within 24 hours after chemical treatment.

(iv) When gas tungsten-arc welding with direct current, straight polarity, is being used, all edges and surfaces to be welded shall have the oxide removed by a standard chemical method.

(v) Welding shall not be done on anodically treated aluminum unless the condition is removed from the joint area to be welded.

(4) (i) All butt welds requiring 100 percent penetration, except those produced with the aid of backing, shall have the root of the initial weld chipped or machined out to sound metal before welding is started from the second side.

(ii) Butt welds made with the use of backing shall have the weld metal thoroughly fused with the backing.

(iii) Where accessible, backing for welds that are subject to computed stress or which are exposed to view on the completed structure and which are not otherwise parts of the structure shall be removed and the joints ground or machined smooth.

(iv) In tubular members, butt welds subjected to computed stresses shall be made with the aid of permanent backing rings or strips.

(5) The procedure used for production welding of any particular joint shall be the same as that used in the procedure qualification for that joint.

(6) Undercut shall not be more than 0.01 inch (0.25 mm) deep when its direction is transverse to the primary stress in the part that is undercut. Undercut shall not be more than 1/32 inch (0.8 mm) deep when its direction is parallel to the primary stress in the part that is undercut.

(7) No overlap shall be allowed.

(8) All craters shall be filled to the full cross section of the welds.

(9) Welds having defects greater than the levels of acceptance specified above shall be considered as rejected unless corrected as indicated below.

(10)All welding operations, either shop or field, shall be protected from air currents or drafts to prevent any loss of gas shielding during welding. Adequate gas shielding shall be provided to protect the molten metal during solidification.

(11)The work shall be positioned for flat position welding whenever practicable.

(12)In both the shop and field, all weld joints shall be dry at the time of welding.

(13)The size of the electrode, voltage, amperage, welding speed, gas or gas mixture, and gas flow rate shall be suitable for the thickness of the material, design of joint, welding position, and other circumstances attending the work.

(14)Gas metal-arc welding shall be done with direct current, reverse polarity.

(15)Gas tungsten-arc welding shall be done with alternating current or with direct current, straight polarity.

(16)(i) When the joint to be welded requires specific root penetration, the Contractor shall make a sample joint and a macroetched cross section of the weld to demonstrate that the joint welding procedure used will attain the required root penetration.

(ii) The sample joint shall have a length of at least 1 foot (300 mm) and shall be welded with the electrode, polarity, amperage, voltage, speed, gas mixture, and gas flow rate that are proposed to be used in production welding.

(iii) Tolerance for variation of amperage and voltage shall be plus or minus 10 percent for amperage and plus or minus 7 percent for voltage during fabrication.

(iv) The Engineer, at his/her discretion, may accept evidence on record in lieu of the preceding test.

(17)Where preheating is needed, the preheating temperature shall not exceed 350°F (177°C) for heat-treated alloys and 600°F (315°C) for non-heat-treated alloys. The temperature shall be measured by temperature indicating crayons or by pyrometric equipment. Heat treated alloys shall not be held at the maximum preheat temperature or at temperatures near the maximum for more than 30 minutes.

c. Weld Quality:

(1) Regardless of the method of inspection, the acceptance or rejection of welds shall be determined by the following conditions:

(i) Cracks in welds or adjacent base metal are not acceptable.

(ii) Copper inclusion is not acceptable.

(iii) Porosity in excess of that allowed by Appendix IV, Section VIII of the ASME Boiler and Pressure Vessel Code will not be acceptable.

(iv) Lack of fusion, incomplete penetration, or tungsten or oxide inclusions are acceptable only if small and well dispersed.

(2) For highway sign structures, the dye penetrant method shall be used on butt welds in columns, main chord members, and on fillet welds connecting columns to bases and main chord members, including the associated flanges, gussets, or main load carrying brackets or members. This method shall also be used on fillet welds connecting flanges to the main truss chord members.

(3) The dye penetrant tests shall be performed in accordance with the requirements of ASTM E 165, Standard Methods for Liquid Penetrant Inspection, Method B.

(4) Dye penetrant inspection may be omitted if the Inspector examines each layer of weld metal with a magnifier (3X power minimum) before the next successive layer is deposited.

(5) Dye penetrant inspection will be required and performed at the Contractor's expense. Personnel performing liquid penetrant inspections shall be qualified as required in AWS. In all cases where the dye penetrant method is done by the Contractor, the inspector must be present when the inspection is made.

d. (1) The Contractor may make the corrections shown in Table 418.03 when a weld is defective. These corrective measures shall be approved by the Engineer before work begins.

Table 418.03
Welding Defects

Problem	Corrective Action
Defective weld	Remove and replace the entire weld.
Cracks in weld or base metal	Determine full extent of crack by dye penetrant method of other positive means. Remove crack throughout its length and depth and reweld.
Excessive porosity, lack of fusion	Remove defective portions and reweld.
Copper or tungsten inclusion	Remove defective portions and reweld.
Excessive concavity of crater, undercut, undersize weld	Clean and deposit additional weld metal.
Overlap	Reduce by removal of excess weld metal.

(2) The Contractor shall remove the defective areas by chipping or machining. Oxygen cutting shall not be used. Before rewelding, the joint shall be inspected to assure that all of the defective weld has been removed. If dye penetrant has been used to inspect the weld, all traces of penetrant solutions shall be removed with solvent, water, heat, or other suitable means before rewelding.

e. Qualification of Procedures, Welders, and Welding Operators:

(1) Joint welding procedures which are to be employed in executing contract work under these *Specifications* shall be previously qualified by tests prescribed in Part B, Section IV, of the ASME Boiler and Pressure Vessel Code. The qualifications shall be at no additional cost to the Department. The Engineer, at his/her discretion, may accept evidence of previous qualifications of the joint welding procedures to be employed.

(2) All welders and welding operators to be employed under these *Specifications* shall be previously qualified by tests as prescribed in Part V, Section IX, of the ASME Boiler and Pressure Vessel Code. The Engineer, at his/her discretion, may accept evidence of previous qualification of the welders and welding operators to be employed. The same process and type of equipment that is required for execution of the construction work shall be used in qualifying welders and welding operators.

f. Steel welding shall be in accordance with Section 708.

4. Inspection of Single Panel or Box Truss Sign Structures:

a. The Contractor shall inspect single panel and box trusses in accordance with Section 708. All mill test reports and certifications shall be furnished to the Engineer before any requests for shop inspection are made.

b. To determine compliance with these welding procedures, all welds shall be visually inspected and a random sample of welds shall be chosen by the inspector to be investigated using dye penetrants.

5. Fastening to Supports:

a. In fastening a sign to the supports, the Contractor shall follow the recommendations of the manufacturer of the extrusheet panels as to frequency of post clamps and torque on nuts.

b. The Contractor shall exercise care in handling and erecting signs so damage is prevented. The Contractor shall replace at no additional cost to the Department any sign which is damaged before final project acceptance.

6. Field Installation of Sign Structures:

a. The Engineer or his designated representative shall be present at all times during pole installation. The Contractor shall notify the Materials and Research Division and Traffic Engineering Division to arrange for inspection no less than 3 days prior to pole installation. No poles installed without proper inspection will be accepted by the state for final payment.

b. Nuts are to be evenly and systematically tightened by the method described by the pole manufacturer in the shop plans. Nuts shall be rechecked for tightness by the Contractor no less than 14 days, nor more than 30 days following installation in the presence of the Engineer. After the structure has been checked, lock nuts shall be installed to keep the nuts from working loose.

c. The Contractor shall dress, as necessary to provide a proper seating of the bases, the areas of the foundation concrete upon which the shafts are to be set before the erection of the aluminum vertical end supports. The bottoms of the supporting shafts and all anchor bolts shall receive a heavy coating of aluminum filled, resilient sealing compound, completely covering all areas of aluminum which may contact the concrete. The compound used shall be on the *NDR Approved Products List*.

d. The Contractor shall assemble the truss sections in the field on the ground and adjust them with shims to provide the camber called for in the plans. While assembled, the truss shall be erected on the end frames in one piece.

e. The end supports shall be erected on the leveling nuts to a truly vertical position and then the top nuts securely tightened to the plate. The grout shall not be placed until the truss has been erected, adjusted, and bolted to final position. The final projection of the base plate above the concrete foundation shall be no greater than the thickness of two leveling nuts.

f. After the structure has been erected and completed and all signs mounted, the area between the top of the foundation and the bottom of the anchor base plates of the vertical end supports shall be filled using a high strength, non-shrink, epoxy based mortar from the Approved Products List. The grouting shall be placed the same day that the uprights are installed on the foundation.

7. Overhead Sign Electrical Requirements:

a. Signs requiring electricity will be identified in the plans.

b. The luminaires shall be on the *NDR Approved Products List.*

c. The sign lighting luminaires shall be mounted as shown in the plans and in accordance with the manufacturer's instructions.

d. The lamps shall be 150 watt high pressure sodium unless shown otherwise in the plans.

e. All conductors shall be copper and shall be installed in conduit. The feeder cable shall be a minimum No. 8 gauge diameter THWN with a 30 ampere circuit breaker at the service entrance. Each sign structure shall be controlled by a 15 ampere 2 pole NEMA 3R breaker at a location convenient for maintenance of the luminaires.

f. Each sign structure shall have a photoelectric control mounted near the sign. The relays for switching the line current to the lighting fixtures shall be mounted near the circuit breaker or as directed by the Engineer. Separate photocells are not required when sign lighting is tied into the roadway lighting.

g. Structure electrical equipment and material, when required, shall be in accordance with the applicable requirements of Section 1073.

8. a. The Contractor shall provide manufacturer-designed steel or aluminum box-truss overhead sign supports or steel brackets attached to a roadway bridge for Type B signs.

b. The structures that will support the Type B signs shall be constructed in conformance with Sections 417, 702, 704, 707, and 708 and as prescribed in the plans.

9. When two or more signs are required on an overhead sign support, the bottom of all signs shall have the same elevation so they will be horizontally aligned with each other. All signs shall be hung at a minimum of 2 feet (600 mm) above the walkway. Sign posts and vertical supports used as sign stiffeners shall be cut off flush with the top of the sign.

10. a. The structure manufacturer shall design and furnish the anchor bolts in accordance with AASHTO M314 grade 55. The maximum allowable shear stress is limited to 20 ksi (140 MPa) fatigue. A bolt sample (including nuts and washers) from each heat of steel used on the project (or multiple projects) shall be submitted to the Materials and Research Division for destructive testing. Threads on anchor bolts shall be rolled in accordance with standard industry practice, the use of cut threads shall not be permitted. The top 12 inches (300 mm) of the anchor bolt shall instead be cleaned and painted with zinc rich paint prior to shipment with a minimum dry film thickness of 4 mils (100 μm). The type of paint and the method of application shall be as approved by the Materials and Research Division. After installation the Contractor shall touch-up threads using approved methods.

b. The nuts shall meet the requirements of ASTM A 914/A 194M, Grade 2H.

c. The hardened steel washers shall conform to the requirements of ASTM F 436 or ASTM F 436M. The plate washer shall conform to the requirements of ASTM A 36/A 36M. Only flat washers shall be used, the use of lock washers shall not be permitted.

d. The manufacturer of the anchor bolts shall furnish certification and test reports covering the steel used. The test report shall show the following:

(1) Chemical analysis of the steel used.

(2) Yield strength in pounds per square inch (MPa).

(3) Tensile strength in pounds per square inch (MPa).

(4) Percent elongation in 2 inches (50 mm).

(5) Percent reduction in area.

418.04 -- Method of Measurement

Overhead Sign Supports are measured by the each.

418.05 -- Basis of Payment

1. **Pay Item**	**Pay Unit**
Overhead Sign Support, Location _____	Each (ea)

2. The reinforced concrete footing and anchor bolts required for the overhead sign support shall not be paid for directly, but shall be subsidiary to the item, "Overhead Sign Support, Location _____".

3. The anchor bolt assemblies shall not be paid for directly, but shall be subsidiary to "Overhead Sign Support, Location _____".

4. Payment is full compensation for all work prescribed in this Section.

SECTION 419 -- PLOWABLE PAVEMENT MARKERS

419.01 -- Description

This work shall consist of furnishing and installing two-way, plowable, all weather, abrasion resistant, prismatic, reflective pavement markers in accordance with the plans.

419.02 -- Material Requirements

1. Only plowable pavement markers that are on the NDR Approved Products List shall be installed.

2. Epoxy shall meet the marker manufacturer's requirements.

419.03 -- Construction Methods

1. The Contractor shall install the plowable markers in accordance with the manufacturer's instructions.

2. The markers shall be free of dirt, dust, oil, grease, rust, moisture, or any foreign matter which will impair adhesion to the pavement at time of installation.

3. Before beginning installation, the Contractor shall accurately and adequately lay out the location of all pavement markers to assure their proper placement and alignment. No marker shall be more than 1/4 inch or 10 degrees out of alignment with the locations shown in the plans.

4. a. Pavement markers shall not be placed on pavement surfaces that show visible evidence of cracking, checking, spalling, or failure of underlying base material.

b. If, during the pre-installation layout operation, it is determined that a marker would be placed at a point with a pavement surface defect, at a pavement construction joint, or within the intersection of a driveway or public street as the result of typical marker spacing, the affected marker shall be relocated longitudinally a sufficient distance to a point not to exceed 10 percent of the typical marker spacing or as approved by the Engineer.

5. a. The Contractor shall saw cut the pavement to the marker manufacturer's recommended dimensions.

b. Before placing the marker in the cut, the cut shall be brushed or blown clean.

c. Epoxy shall be placed in the cut in accordance with the manufacturer's recommendation.

d. The Contractor shall apply constant foot pressure for 30 seconds to seat the marker in the epoxy.

e. The 4 lugs on the marker shall rest on the pavement.

6. At the end of each day, markers shall be set and epoxied in place in all marker cuts.

7. a. The Contractor may attach the prismatic reflector to the casting in the field or in a shop.

b. If the reflector is attached in the field, it shall not be attached to the casting until after the adhesive in the pavement slots has properly hardened.

c. Any rust or foreign matter shall be removed from the surface of the casting on which the reflector is to be attached. The recessed attachment area shall be painted with an adhesive primer in accordance with the manufacturer's instructions.

d. The release paper shall then be peeled from the butyl adhesive on the bottom of the reflector, and the reflector shall be inserted into the recessed attachment area and pressed into place until a firm bond has been made with the casting.

e. The Contractor shall press the reflector into place with constant foot pressure applied for 30 seconds.

8. When the Contractor is required to remove and reinstall plowable pavement markers, the markers shall be refurbished to a like new condition before reinstallation. New reflectors shall be installed in the casing as part of the refurbishment process.

419.04 -- Method of Measurement

Plowable pavement markers will be measured for payment by the each.

419.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Plowable Pavement Marker	Each (ea)
Install Pavement Marker	Each (ea)
Remove and Reinstall Pavement Marker	Each (ea)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 420 -- DELINEATORS

420.01 -- Description

1. The Contractor shall furnish and install roadside delineator units in accordance with the details shown in the plans. A delineator unit shall consist of round, acrylic plastic, prismatic reflector(s) mounted on a post. The delineator unit shall be installed at the locations shown in the plans or designated by the Engineer.

2. The prismatic reflectors to be installed on the delineator shall be as follows:

a. Delineators, Type I -- One circular prismatic reflector and post.

b. Delineators, Type II -- Two circular prismatic reflectors mounted vertically on the same side of the post.

c. Delineators, Type III -- Two circular prismatic reflector units mounted back-to-back on a single post.

3. Flexible post delineators shall be installed with one or two 3-inch wide by 9-inch long micro-prismatic reflecting sheeting plates as shown in the plans.

4. Reflectors on the left side of divided streets and highways and one-way roadways shall be yellow in the direction of travel. All other reflectors shall be white.

5. Chevrons are usually Manual on Uniform Traffic Control Devices, W1-8 (18”x24”) (450 mm x 600 mm) or as indicated in the plans.

420.02 -- Material Requirements

1. All reflectors for delineators and all flexible delineator posts shall be on the NDR Approved Products List.

2. Before ordering any materials, the Contractor shall submit, for approval, the manufacturer's name and identifying information on the proposed delineator unit. There shall be no substitution subsequent to approval without the prior written permission of the Engineer.

3. Flexible Delineator Posts

a. The post material shall be rubber, plastic, or any other material which meets physical test requirements and results in little or no damage to impacting vehicles.

b. The post shall be black.

c. The top 11 inches (275 mm) of the post shall be flattened to approximately a 3-inch (75 mm) width to provide surfaces to mount reflectors.

d. A piece of white or yellow (as required by the plans) reflective sheeting, no smaller than 3 inches x 9 inches (75 mm x 225 mm) shall be placed no more than 2 inches (50 mm) from the top of the post.

e. The reflective sheeting shall be ASTM D 4956 Type IV or V reflective sheeting.

4. The materials used shall conform to the requirements of Sections 1070 and 1072.

5. Steel posts shall conform to the requirements of Subsection 1071.02.

6. The highway signs and reflectors shall also conform to the requirements of Sections 1070 and 1072.

7. The Department will provide the chevrons which are to be mounted on delineator posts.

420.03 -- Construction Methods

1. a. The normal mounting height is shown in the Standard Plans or the contract plans. However, the Engineer may require other mounting heights.

b. All posts on which chevrons are mounted shall be metal posts.

c. When required, the chevron will include the delineator reflector.

2. Flexible posts shall be anchored using a galvanized anchor that is recommended by the manufacturer for the soil type at the installation location.

420.04 -- Method of Measurement

1. "Delineator, Type _____" will be measured by the each.

2. Flexible post delineators are measured by the each.

3. Chevrons are measured by the each per post regardless of their size. If a post requires two chevrons, it will be treated as one for payment.

420.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Delineator, Type _____	Each (ea)
Flexible Post Delineator	Each (ea
Install Chevron	Each (ea)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 421 -- REMOVING AND RESETTING DELINEATORS

421.01 -- Description

The Contractor shall remove and reset flexible post and standard delineators at the locations shown in the plans.

421.02 -- Construction Methods

1. The Contractor shall remove the delineators, intact, and stockpile them at designated locations for future resetting.

2. Any material lost or damaged shall be replaced by the Contractor at no additional cost to the Department.

3. The delineators shall be set plumb and anchored as prescribed in the plans.

421.03 -- Method of Measurement

Removing and resetting delineators will be measured by the each.

421.04 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Remove & Reset Delineators	Each (ea)
Remove & Reset Flexible Post Delineators	Each (ea)

2. Payment is full compensation for all work prescribed in this Section.

SECTION 422 -- TEMPORARY TRAFFIC CONTROL DEVICES

422.01 -- Description

1. This work consists of furnishing, installing at the locations shown in the plans, operating, maintaining, and when work is complete, removing the temporary traffic control devices described in this Section.

2. General Requirements:

a. All traffic control devices shall be located according to and meet all requirements prescribed in the MUTCD. Failure of the Contractor to erect and maintain traffic protective devices shall be reason to temporarily suspend the work in accordance with Subsection 108.06.

b. (1) All barricades and signs shall be constructed and erected in accordance with the plans. Type A, B, and C barricade lights shall be on the NDR approved Products List.

(2) Temporary signs and temporary (portable) sign supports shall meet Natoinal Cooperative Highway Research Program (NCHRP) Report 350 test level 3 requirements.

(i) The Contractor shall furnish “Temporary Signs”. The Contractor shall install “Temporary Signs” at the locations shown in the plans, maintain “Temporary Signs”, and, when no longer needed, remove the “Temporary Signs”.

(ii) Any project let prior to January 1, 2002 with a scheduled start date after January 1, 2002 or with a substantial amount of work remaining after January 1, 2002 will require that all “Temporary Sign” supports (bases) are NCHRP 350 (TL-3) approved.

(iii) “Temporary Signs” are all temporarily mounted work zone signs that are not post-mounted in the ground at the typical 7’ mounting height. Temporary signs are considered NCHRP 350 category 2 devices and are mounted on temporary sign stands. Temporary signs are generally mounted a minimum of 1’ above the ground, unless otherwise required to be mounted at a higher height.

c. The initial placement, replacement, and removal of the lane dividers and other traffic control devices shall be done with extreme care and consideration for the traveling public.

d. Traffic control devices shall not be removed without the Engineer's approval.

e. The barricades and other traffic control devices, except materials furnished by the Department, shall remain the property of the Contractor.

f. (1) The Contractor shall provide hard covers for signs lift in place and currently not in use.

(2) The covers shall be the same size as the sign and completely cover the sign when installed.

(3) Bolting the cover to the sign by drilling holes through the sign will not be allowed.

(4) The cover shall be constructed so there will be at least a 1/8 inch space between the sign and the cover when installed.

(5) The cover will be fastened so that it will not come loose or damage the sign during normal or windy conditions.

(6) Spacer blocks are allowed in the border area of the sign.

g. The Contractor shall maintain a stock of spare lights, signs, devices, and repair parts at the project site for immediate emergency replacement or repairs.

h. The Contractor shall mow or trim vegetation to insure that the complete visibility of signs, barricades, and other warning devices is maintained at all times.

i. The Contractor shall, at the preconstruction conference, provide the Engineer with the names and telephone numbers of personnel who will be available on a 24-hour-per-day, 7-days-per-week basis. These people shall be responsible for repair, correction, replacement, and maintenance of the traffic control devices.

j. (1) The Contractor shall take all necessary precautions for the protection of the work and the safety of the public.

(2) (i) The Contractor shall be alert at all times to any and all deficiencies in the placement and maintenance of any traffic control devices and shall take immediate action to correct any deficiencies.

(ii) The Contractor shall inspect traffic control devices at least once every day the devices are in use, but shall provide more frequent inspections during or following periods of inclement weather or at other times when more frequent inspections are warranted.

(3) Type A, B, and C barricade warning lights shall comply with the requirements for warning lights in the MUTCD.

k. (1) The Contractor may be given notice, either written or verbal, of failure to install, replace, remove, or maintain a traffic control device.

(2) Upon notification by the Engineer, the Contractor shall respond to any site within 4 hours and take immediate steps to correct the deficiency.

(3) If corrective action is not taken by the Contractor within 4 hours of the initial notice, the Engineer shall make no payment for any traffic control devices for that day.

(4) If corrective action is not taken within 4 hours, a written notice of action to be taken shall be given to the Contractor or person designated for work zone traffic control.

(5) Failure to install, replace, remove, or maintain a device within 8-hours of the initial notice may result in no payment being made for any traffic protective devices on the project for that day and on subsequent days until the requested installation, replacement, removal, or maintenance is performed. The Engineer may also suspend all other work until the problem is corrected.

l. The Department may elect at any time to correct a traffic control deficiency and bill the Contractor for all costs necessary to correct the problem.

m. The Contractor shall immediately notify the Engineer of any hazard or changed roadway condition that is not identified in the plans.

n. When more than one Contractor is working on the project or when consecutive projects require protection and control of traffic, the Engineer shall determine and notify in writing the Contractor whose responsibility it shall be to provide the protection and control of traffic.

o. When a pilot vehicle is required by the contract, it shall be used to lead the traffic through the restricted section. The work shall be so coordinated that the pilot vehicle shall make a round trip in 15 minutes or less.

3. Asphalt Pavement:

a. The Contractor shall control the traffic to protect any new bituminous surface work including patches, prime coat and track coat as described in Division 500 and the plans.

b. Public traffic will not be allowed on new asphalt surfaces until compaction rolling is complete and the surface has cooled to less than 165°F (74°C).

c. When a detour is not shown in the plans, the Contractor may restrict the traveling public to one-way traffic. This restriction shall be limited to the minimum time and distance required to properly compact the mixture and allow sufficient reduction in temperature to prevent displacement of the surface or damage to the surface treatment and/or edges of the newly placed surface. Two-way traffic shall be allowed on the remainder of the project unless there are other traffic restrictions.

d. When traffic is restricted to one lane, the Contractor shall place at least one flagger at each end of the restricted section.

4. Temporary Pavement Markings:

a. (1) The pay item "Temporary Pavement Marking, Type _____" has 4 options and is used on major construction such as phased PCC pavement, bridges, and shooflys.

- Temporary Pavement Marking, Type I (Tape)
- Temporary Pavement Marking, Type II (Tape)
- Temporary Pavement Marking, Type Paint.
- Temporary Pavement Marking, Type RPM

(2) The pay item "Temporary Pavement Marking" has 4 optional materials unless otherwise restricted by the plans or other contract documents. The options are:

- Temporary Pavement Marking, Type I (Tape)
- Temporary Pavement Marking, Type II (Tape)
- Temporary Pavement Marking, Type Paint.
- Temporary Pavement Marking, Type RPM

(3) The application and type of pavement marking to be used shall be as specified in the project plans or as directed by the Engineer.

(4) All temporary pavement marking shall conform to the requirements in this Section for materials, equipment used, application, measurement and payment.

b. (1) The pay items “Overlay Broken Lines” and “Overlay Solid Lines” are used to provide and apply lines on asphalt pavement where the marking is renewed at the end of each day as in overlay work.

(2) Both pay items have four optional materials:

(i) Paint (see Paragraph 4.d. below for requirements)

(ii) Tape – Type I (see Paragraph 4.d. below for requirements)

(iii) Tape – Type II (see Paragraph 4.d below for requirements)

(iv) Raised pavement markers (see Paragraph 4.g. below for requirements)

(3) Plans will indicate the appropriate marking material to be used. If the plans or other contract documents do not indicate the type of material, then the Contractor may select any of the four options.

c. Temporary Pavement Marking, Type Paint:

(1) This work shall consist of the placement of white or yellow paint stripes with embedded glass beads for retroreflectivity. The paint stripes shall be the color, size, and type specified. They will be placed in the locations specified in the project plans or as directed by the Engineer.

(2) Temporary Traffic Paint that fails to provide a uniform appearance, or which fails to be clearly visible during the day or night shall be corrected or replaced by the Contractor in a manner acceptable to the Engineer and at no additional cost to the Nebraska Department of Roads.

(3) The paint machine shall be capable of applying an even, clean-cut line without excessive drifting of paint. The cutoff mechanism on the paint machine shall be capable of making a clean-cut end section without dripping or stringing fine lines of paint.

(4) The bead dispenser shall be equipped with an automatic cutoff control synchronized with the cutoff on the striping material.

d. Temporary Pavement Marking, Type I and II (tape):

(1) This work shall consist of the application of preformed temporary pavement marking tape meeting the materials requirements of section 1069.02 paragraphs 1 and 2 of the current Nebraska Department of Roads, Standard Specifications for Highway Construction.

(2) Type I tape will generally be used for asphalt projects.

(3) Preformed pavement line markings consisting of Type I and II tape shall be installed with a mechanical applicator, which shall be capable of placing pavement lines in a neat, accurate and uniform manner. The mechanical applicator shall be equipped with a film cut off device.

e. “_____Temporary Pavement Marking Type_____” is the pay item for temporary arrows, words, and symbols on all asphalt and PCC pavement.

These markings can be either painted with beads or tape as indicated in the pay item.

f. Temporary pavement marking ("Temporary Pavement Marking, Type _____" and "Temporary Pavement Marking", and "_____ Temporary Pavement Marking, Type ___") includes removal of the markings when they are no longer needed at no additional cost to the Department.

g. The Engineer may approve the use of raised pavement markers for yellow solid lane lines with a maximum spacing of 5 feet (1.5 m). They may also be used as right edge lines, but **only** when shown in the plans.

h. Any broken or solid lines that fail to meet dimensions or spacing in Tables 422.01 and 422.02 shall not be accepted and no payment will be made for **all** pavement marking applied that day, until correct installation (to the satisfaction of the Engineer) resumes.

i. Raised pavement markers and paint or tape shall not be interspersed or used with each other to simulate the same line. However, they may be used together to supplement a line when required by the plans or the Engineer.

j. The plans and the Specifications will indicate where each type of temporary pavement marking will be applied. The Engineer may direct the Contractor to apply any of the four optional temporary pavement marking line materials as are necessary for safe traffic flow.

5. National Cooperative Highway Research Program (NCHRP) Report 350 Requirements.

a. Contractor furnished traffic control devices shall be crashworthy and qualify as such according to the testing and acceptance guidelines of the National Cooperative Highway Research Program (NCHRP) Report 350. Traffic control devices have been classified into four (4) categories. The following is a list of categories and compliance requirements.

(1) **Category 1: I**ncludes traffic cones, tubular posts, vertical panels, flexible delineator posts, and reflectorized plastic drums with no attachments. The Contractor shall provide the Engineer a copy of the developer's self-certification of the devices used.

(2**) Category 2: I**ncludes Type II and III barricades, portable sign supports, intrusion alarms and cones, vertical panels and plastic drums with a light or sign attached. The following compliance requirement for Category 2 devices shall be used:

(i) By January 1, 2002, all Category 2 devices shall be NCHRP 350 (Test Level-3) compliant.

(ii) All new Category 2 devices purchased or built after October 1, 2000 shall be NCHRP 350 (TL-3) compliant; and Contractors shall certify that all devices purchased or built after October 1, 2000 are NCHRP 350 compliant.

(iii) Projects let prior to October 1, 1999 will not be subject to this provision.

(iv) Projects let after January 1, 2002 will require that all Category 2 devices are NCHRP 350 (TL-3) compliant.

(v) For projects let after October 1, 1999 but prior to January 1, 2002, the Category 2 devices used may be either compliant devices or non-compliant devices purchased prior to October 1, 2000 completing their normal service life. For projects let during this period with a starting date after January 1, 2002, all Category 2 devices shall be NCHRP 350 (TL-3) compliant. For projects let during this period but not completed by January 1, 2002, the Department of Roads --- at its discretion --- will determine whether non-compliant devices may remain in service. If the Department directs that non-compliant devices be replaced with compliant devices, the Contractor will be compensated for the replacement as extra work. Compensation will be based upon the actual cost of the replacement less any residual value of the new devices upon completion of the contract.

(vi) The Contractor shall provide the Engineer a copy of the FHWA acceptance letter for all NCHRP 350 (TL-3) compliant Category 2 devices when used.

(3) **Category 3: I**ncludes concrete protection barriers, fixed sign supports, truck mounted attenuators (TMA), and work zone crash cushions (WZCC) and other work zone devices not meeting Category 1 or 2.

(i) TMA's and WZCC purchased after October 1, 1998 must comply with NCHRP 350 TL-3. Existing TMA's and WZCC may be phased out as they complete their service life. Concrete protection barriers purchased after October 1, 2002 shall meet NCHRP 350 TL-3.

(ii) The Contractor shall provide the Engineer a copy of the FHWA acceptance letter for all NCHRP 350 (TL-3) Category 3 devices when supplied by the Contractor.

(iii) Fixed breakaway sign supports for work zones shall be tested under the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, and accepted by the FHWA.

(4) **Category 4:** Includes portable or trailer-mounted devices, such as flashing arrow panels, temporary traffic signals, area lighting supports and portable changeable message signs. The compliance date for Category 4 devices has not been determined.

422.02 -- Material Requirements

1. a. Warning Signs – The Department will furnish the permanent sign messages on an appropriately sized panel at one of the permanent maintenance headquarters located throughout the State. These are as follows:

Maintenance Headquarters			
Ainsworth Alliance Bridgeport Broken Bow Chadron Columbus Fairbury Fremont	Geneva Grand Island Hastings Holdrege Imperial Kearney Lincoln McCook	Mullen Neligh Norfolk North Platte Omaha O'Neill St. Paul	Scottsbluff Sidney South Sioux City Tecumseh Valentine Wayne York

b. Temporary Signs

(1) Contractor-furnished "Temporary Signs" shall consist of approved retroreflective fluorescent orange or white roll-up signs mounted on temporary sign stands. The sign with stand shall be NCHRP-350, Test Level 3, approved. The roll-up signs shall be of the size and shape required by the plans. The color and design of the roll-up signs shall be as required by the MUTCD and the NDR Traffic Engineering Division. Sign legends and symbols shall be of professional quality workmanship and in uniformity with the Standard Highway Signs design guide. Temporary signs shall meet the requirements of the American Traffic Safety Services Association (ATSSA). "Quality Standard for Work Zone Traffic Control Devices", hand printing or poor workmanship shall not be allowed. The Contractor shall provide the Engineer a copy of the FHWA acceptance letter for all Category 2 "Temporary Signs" before they are used.

(2) Rigid plastic sign substrates that have been approved to NCHRP 350 (TL-3) may be used for roll-up signs. When used, the plastic sign substrate with sign sheeting and temporary sign support shall, all together as a single, testing unit, be NCHRP 350 (TL-3) approved. Aluminum sign substrates shall not be used.

(3) The temporary sign stands have enough vertical rigidity to support the roll-up signs in an upright position and provide continuous legibility of the sign legend in gusty conditions (wind or vehicle gusts). The Engineer shall determine the adequacy of visibility, and temporary sign stands that fail to provide adequate visibility of the sign shall not be allowed.

(4) Retroreflective, orange fluorescent sheeting used for temporary, roll-up signs shall be 3M diamond grade roll-up sheeting or Reflexite Marathon fluorescent sheeting or other approved equal material. Retroeffective white sheeting shall be 3M diamond grade roll-up sheeting or Reflexite Marathon white sheeting or other approved equal material.

(5) Signs required for flagging shall meet the "Temporary Sign" requirements of this Section (422).

2. The following items shall meet the requirements prescribed in the *Manual on Uniform Traffic Control Devices*:

a. Barricades (Type II & III)

b. Temporary Traffic Signals

c. Concrete Protection Barriers

d. Vertical Panels

e. Type B High Intensity Warning Lights

3. The following items must be on the NDR Approved Products List to be used on a Department project:

a. (1) Temporary Pavement Marking, Type I, II, & RPM.

(2) Overlay Broken Lines and Overlay Solid Lines (Type I, II, & RPM).

b. Inertial Barrier Systems

c. Flashing Arrow Panels

d. Tubular Posts

e. Opposing Lane Dividers

f. Temporary Glare Screen

g. Changeable Message Signs

h. 42" (1070 mm) Reflective Cones

4. Temporary Pavement Marking, Type Paint and "Overlay Broken/Solid Lines (Paint)" shall meet the following requirements:

a. **Paint.** The paint shall be commercially available traffic paint capable of receiving and holding glass beads for producing reflectorized traffic markings. The paint shall be furnished ready mixed and shall not be diluted or thinned. The paint shall be compatible with drop-on floating conventional beads. The color for white paint after drying shall be a flat white, free from tint, furnishing good opacity and visibility. For yellow, the color shall closely match Color Chip 33538 of Federal Standard 595.

b. **Beads.** The glass beads shall be AASHTO M-247 Type 1, Floating. The beads shall be free from clumps and suitable for application to the type of paint selected by the Contractor. The glass beads shall show good adherence to the paint binders and provide good night visibility throughout the manufacturer's predicted useful life of the reflectorized binders. The beads shall allow sufficient capillary action to form a firm embedment in typical traffic paint when dropped on a freshly applied paint film. The beads shall be accepted based on certified test results indicating that the beads meet the specifications for AASHTO M-247 Type 1, Floating beads and the above requirements.

5. The reflective sheeting on 42-inch (1067 mm) cones shall be 3M scotchlite diamond grade fluorescent orange flexible sheeting or an approved equal quality sheeting.

422.03 -- Construction Methods

1. a. The Contractor shall install, maintain, and remove all signs in accordance with the details of and at the locations shown in the plans.

b. The Contractor shall furnish all necessary posts, support standards, bolts, or other fasteners for signs.

c. For the purpose of protecting and controlling traffic through or around a construction project, permanent signs are defined as those signs which provide protection and control on a 24-hour-per-day basis. All other signs shall be considered as temporary signs, including signs designated in the plans as "Temporary Signs", which must remain in place for variable periods of time. Construction speed zone signing shall be considered temporary signing and shall only be installed during those periods when the speed zone is required.

d. Permanent signs, complete with posts, bolts, or other fasteners, shall be placed at the time construction work begins in compliance with the applicable conditions of the standard and/or special plan(s) and shall be used until permission is granted, in writing, by the Engineer that the work is complete and that they may be removed.

e. Posts used to erect permanent signs shall be installed and maintained plumb, and the sign faces shall be positioned and maintained so that they face approaching traffic.

f. Signs shall be disassembled and returned to the maintenance headquarters from which they were obtained, or to a location designated by the Engineer, during normal working hours.

g. (1) Signs returned to the Department shall be in reusable condition.

(2) Wood signs shall not be marred or damaged to the extent that they will be unsightly.

(3) Aluminum signs shall not be marred, damaged, bent, or contain holes other than necessary bolt holes.

(4) If signs are damaged while issued to the Contractor, then the Contractor will be charged the replacement cost.

h. Steel drums shall not be used as sign holders.

i. (1) “Temporary Signs” shall be installed as shown in the “plans”, “Standard Plans”, or “Special Plans”.

(2) “Temporary Signs” shall be installed as prescribed in the MUTCD.

2. Barricades:

a. This work consists of providing, installing, maintaining, and when no longer required, removing barricades and reflectorized drums at the locations shown in the plans or designated by the Engineer.

b. The *Manual on Uniform Traffic Control Devices* defines 2 types of barricades authorized for use in Nebraska:

(1) Type II

(2) Type III

c. In applications other than on a freeway, expressway, or an interstate roadway, reflectorized drums may be used in lieu of Type II Barricades. Reflectorized drums shall be used in lieu of Type II Barricades in applications on a freeway, expressway, or an interstate roadway.

d. When approved by the Engineer or shown in the plans, 42" (1070 mm) reflective cones may be used in lieu of Type II Barricades or Reflectorized Drums. 42" (1070 mm) reflective cones shall include a 30-pound (14 kg) rubber base and display four 6-inch (150 mm) wide bands of 3M Scotchlite diamond grade fluorescent orange flexible sheeting or an approved equal quality sheeting. The bands shall alternate orange-white-orange-white. 42" (1070 mm) reflective cones shall not be used for lane-closure tapers or shifts, or the dropoff at the edge between the pavement and the shoulder.

3. Flagging:

a. (1) It shall be the responsibility of the Contractor to furnish flagger(s) to direct traffic when construction activity occurs on or adjacent to a surface being used by the traveling public.

(2) Except when necessitated by an emergency situation or for situations not reasonably expected to last for more than 15 minutes, flagging shall not be performed by other than certified flaggers. Flaggers must always carry a valid Flagger Certification Card. Flagger Certification Cards shall be valid for a period of 2 years from date of issue.

b. (1) The flagger(s) shall be properly attired with vest and head gear. They shall be provided properly installed advance warning signs, and they shall be otherwise equipped in accordance with the requirements of the plans and specifications.

(2) Flaggers shall position themselves appropriately and according to accepted flagging procedures.

c. (1) The Contractor shall be responsible for the training and certification of the flaggers employed on the project. Certification shall be according to the standards established herein and the "Guidelines for Flagger Training and Certification of Flaggers" available from the Department. Certification cards issued according to these rules by other Contractors, provided they have not expired, shall be considered valid.

(2) Flaggers shall be familiar with the contents of the Department's "Flagger's Handbook" and shall carry a copy of such publication on their person while performing the flagger duties. This publication is available from the Engineer.

d. In order to be certified, the prospective flagger must:

(1) Be in good health with normal abilities or hearing and sight.

(2) Be able to read and speak English.

(3) View the 45-minute video "The Flagger."

(4) Correctly answer 80 percent of the questions on an examination that accompanies the video.

e. Upon satisfactory completion of the training and examination procedure, the prospective flagger shall be issued a Flagger Certification Card by the examining Contractor. The flagger's name, social security number, and test score shall be reported to the Construction Engineer on DR Form 90, "Flagger Certification Report".

f. The video, examination forms, Flagger Certification Cards, Flagger Certification Reports, and "Guidelines for Flagger Training and Certification of Flaggers" shall be furnished by the Department.

4. Temporary Traffic Signal:

a. Temporary traffic signal systems shall be furnished, installed, operated, and maintained by the Contractor at the locations shown in the plans.

b. "Temporary Traffic Signal" shall include signal heads for all approaches to the signal. A temporary traffic signal for a single lane roadway section or bridge shall include signal heads for both ends of the single lane section.

c. (1) The Contractor shall make arrangements with the local utility for power service for temporary signals in a timely manner.

(2) The Contractor is required to comply with the local utility's policy for temporary power service.

(3) The Contractor shall cooperate with the local utility in scheduling the installation.

(4) Any delay resulting from a Contractor's untimely request to the local utility for temporary power service shall not be justification for the suspension or adjustment of the working days or calendar days on a project.

d. When work is complete, the Contractor shall remove the traffic signal.

5. Concrete Protection Barriers:

a. (1) Concrete protection barriers shall be furnished by the Department and installed by the Contractor at the locations shown in the plans or designated by the Engineer for the pay item "Install Concrete Protection Barrier".

(2) The Contractor shall furnish and install concrete protection barriers at the locations shown in the plans or designated by the Engineer for the pay item "Concrete Protection Barrier".

(3) The repositioning of concrete protection barriers to locations directed by the Project Manager or as shown in the plans after the initial installation is included in and defines when the pay item “Relocate Concrete Protection Barrier” is used.

b. The Contractor shall obtain and return the concrete barriers to the location(s) indicated in the plans. These units, which are 2 feet wide by 10 feet long by 32 inches high and with weigh approximately 4,900 pounds, shall be installed as shown in the plans.

c. The barrier unit ends shall be placed as close together as possible and in close alignment.

d. Adjacent ends of the barrier units shall be fastened together as directed by the Engineer.

e. The Contractor shall shim the barrier units as necessary to compensate for surfaces that are not level.

6. Temporary Pavement Marking/Overlay Solid Lines/Overlay Broken Lines:

a. (1) The Contractor shall install reflectorized temporary pavement markings of the color, width, line configuration, and dimensions shown in the

plans or designated by the Engineer. Work includes arrows, words and symbols marked on the pavement.

(2 When markings are no longer needed, the Contractor shall remove them at no additional cost. **If removing markings from the final wearing surface, the removal process shall not mar or damage the surface. Removed marking shall no longer be visible on the final wearing surface.**

(3) When "over" painting existing lines, the pattern shall match the existing pattern.

b. Temporary Pavement Marking, Type I and Type II (tape) and Overlay Solid Line (tape) shall be placed to form a continuous line when used as a solid line, breaking only at intersections

c. Raised pavement markers shall not be used for right edge lines unless shown in the plans.

d. (1) When temporary pavement markings (including "Overlay Broken Line") are used to delineate lanes with broken lines in rural areas, the following **minimum dimensions shall** be used:

Table 422.01
Rural Area

Marking	**Minimum Dimension**
Temporary Traffic Paint	Minimum 4 inches (100 mm) wide by **10 feet (3 m) long** with 30 foot (9 m) max. gaps.
Temporary Pavement Marking Tape	Minimum 4 inches (100 mm) wide by **4 feet (1.2 m) long** placed every 40 feet (12 m).
Raised Pavement Markers	3 markers, each a maximum of 5 feet (1.5 m) apart with 30 foot (9 m) gaps.

(2) When temporary pavement markings (including "Overlay Broken Line") are used for lane delineation with broken lines in urban areas, the following **minimum dimensions shall** be used:

Table 422.02
Urban Area

Marking	Minimum Dimension
Temporary Traffic Paint	Minimum 4 inches (100 mm) wide by **6 feet (2 m) long** with 18 foot (5.5 m) max. gaps.
Temporary Pavement Marking Tape	Minimum 4 inches (100 mm) wide by **2 feet long** (600 mm) placed every 20 feet (6 m)
Raised Pavement Markers	3 markers, each a maximum of 3 feet (900 mm) apart with 18 foot (5.5 m) gaps.

e. In order to insure maximum adhesion, the Contractor shall clean all dirt, glaze and grease, road film, and all other foreign materials from the pavement area to be marked. The pavement shall be clean and dry prior to the application of the temporary pavement marking.

f. Pavement markings which fail to provide a uniform appearance, fail to be clearly visible during the day or night, or which fail to remain firmly in place on the roadway shall be replaced or corrected by the Contractor in a manner acceptable to the Engineer and at no additional cost to the Department of Roads.

g. To insure the satisfactory performance of pavement mark-ings, new portland cement concrete pavement shall be sandblasted to remove the curing compound from the surface on which pavement markings are to be applied. Sandblasting may be done seven days after the placement of the concrete surface unless otherwise directed by the Engineer.

h. Temporary Pavement Marking, Type Paint and Overlay Solid/Broken Lines (Paint):

(1) The material shall be applied to the pavement at a minimum wet film thickness of 0.015 in. (.38 mm).

(2) The beads shall be distributed evenly over the wet paint at a reasonably accurate rate of 5 pounds per gallon (0.60 kg/l) of paint, unless the Engineer specifies a different rate. Beads applied to the surface of the completed stripe shall be applied by an automatic bead dispenser attached to the striping machine in such a manner that the beads are dispensed immediately upon the completed line.

(3) The paint shall be applied in such a manner as to follow the existing lines on the roadway or as directed by the Engineer. When deemed necessary by the Engineer to achieve the correct alignment, the Contractor shall, at no additional cost to the Department of Roads, place additional markings to guide the placement of the lines. The guide markings shall be temporary in nature and the material and equipment used to place these guidelines shall be approved by the Engineer.

(4) The completed line shall be a uniform cross section. The traffic paint stripe shall not be applied when there is moisture on the pavement that would cause a poor bond between the paint and the pavement.

(5) Application shall not be permitted when atmospheric temperature is below 40° F (4° C) and falling.

(6) The Contractor shall follow all manufacturer recommendations for application of traffic paint so as to obtain the best results.

(7) The paint shall be applied 4 ± 1/2 inches (100 mm ± 12 mm) in width with a dry thickness of at least 10 mils (0.25 mm) (approximately 10.7 gallons of paint per mile (25.2 l/km) of solid line).

(8) The equipment used to paint the line shall be designed to apply painted traffic lane markings of the type, width, and thickness required.

(9) The machine shall be equipped with an adjustable guide to assure the line's proper placement. Hand application or towing of the equipment will not be allowed, except in emergency situations.

(10)The Contractor shall remove all temporary lines when they are no longer needed. If removing markings from the final wearing surface, the removal process shall not mar or damage the surface. Removed markings shall no longer be visible on the final wearing surface.

i. Projects without Detour:

(1) Not more than 1/2 mile (0.8 Km) of roadway behind the finish rolling operation, completed asphaltic surface treatment, or the milling operation shall be unmarked. At the end of each day, the temporary lines shall be placed so that, when combined with existing or previously placed lines, the entire project is marked. The Contractor shall clean or replace all temporary marking and reflective surfaces at no additional cost to the Department.

(2) When raised pavement markers, paint or tape is applied and the adjacent layer of asphaltic concrete has not been placed, the markings shall be placed on the higher layer approximately 6 inches (150 mm) from the longitudinal joint. The Contractor shall be required to remove the raised pavement markers and the overlay markers on all lifts.

(3) The top layer shall be marked with three raised pavement markers placed at 5 foot (1.5 m) spacing approximately 6 inches (150 mm) off centerline at 40 foot (12 m) intervals or 4 inch (100 mm) by 48 inch (1.2 m) reflectorized tape every 40 feet (12 m).

(4) When possible, the location of the temporary edge line should coincide with the permanent line in its final position.

j. Projects with Detour:

(1) A temporary centerline will be required for all layers of asphaltic concrete placed. Lower layers shall be marked with reflectorized tape or paint applied in sections 4 inches (100 mm) by 24 inches (600 mm) at 40-foot (12 m) intervals, 4 inch (100 mm) by 10 foot (3 m) painted line with 30-foot (9 m) gap, or three raised pavement markers at 5 foot (1.5 m) spacing placed

approximately 6 inches (150 mm) off centerline at 40-foot (12 m) intervals. The Contractor shall remove raised pavement markers before successive resurfacing operations.

(2) The top layer shall be marked with three raised pavement markers placed approximately 6 inches (150 mm) off centerline at 40-foot (12 m) intervals or 4 inch (100 mm) by 48 inch (600 mm) reflectorized tape every 40 feet (12 m).

k. The Engineer may direct that raised pavement markers are left in place. The Engineer shall consider the RPM's location and color.

7. Temporary Rumble Strips:

a. The Contractor shall furnish, install, and maintain temporary rumble strips at the locations shown in the plans or directed by the Engineer.

b. The material shall be given adequate time to harden before the rumble strips are opened to traffic.

c. Upon completion of that particular phase of the work requiring rumble strips, the Contractor shall remove the rumble strips. The Contractor shall exercise the same care and consideration for traffic control during removal operations as that required for the initial installation or replacement.

8. Vertical Panels:

The Contractor shall furnish, install, and maintain vertical panels at the locations and spacing shown in the plans or designated by the Engineer. The vertical panels shall comply with the requirements shown in the MUTCD and any pertinent modifications shown in the plans. A vertical panel unit may be single- or double-sided (back-to-back) as required by the plans, and the supporting post shall not cover any of the reflective area of the panel(s).

9. Inertial Barrier System:

a. This work shall include the furnishing and installation required for project phasing, and removal of sand-filled type inertial barrier systems, including filler material and object markers, in accordance with the plans or as required by the Engineer.

b. (1) The Contractor shall furnish an FHWA approved inertial barrier system that is on the NDR Approved Products List.

(2) The system shall be installed in the field as required by the manufacturer.

(3) The sand or filler material for the inertial barrier system shall meet one of the material and graduation requirements of fine aggregate for concrete.

(4) A complete set of replacement modules shall be available near the project site in the event of damage to the installed system. Damaged modules shall be replaced within 24 hours.

(5) For inertial barriers which are required to remain in place during the winter, 5 to 15 percent (by volume) rock salt shall be mixed with the filler material.

(6) Upon completion of the work requiring the inertial barrier system, the Contractor shall remove the system and clean the site of any debris and filler material remaining from the system.

c. Inertial barrier modules shall be available in 200, 400, 700, 1,400, and 2,100 pound sizes and shall consist of the following components:

(1) An outer container molded in one or two pieces. The material shall be durable, weatherproof, and formulated to resist deterioration from ultraviolet rays. The outer container shall have a minimum width of 27 inches at the base, 36 inches at the top, and a minimum height of 36 inches. The standard color shall be yellow.

(2) A lid which locks securely to the top lip of the outer container. The material shall be durable, weatherproof, and formulated to resist deterioration from ultraviolet rays. The lid shall be capable of withstanding a 200 pound vertical load.

(3) A supporting insert which is varied to allow for different sizes of modules to support 200, 400, 700, and 1,400 pound sand weight. Care shall be taken to fill each module with the proper amount of sand as called for in the array design. The height and diameter of the inserts shall be such to ensure that the center of gravity of each module is at the proper elevation to control the attitude of impacting vehicles. The insert container interface shall allow free drainage of excess water contained in the sand mass.

d. A MUTCD Type I object marker shall be placed on the first inertial barrier module facing approaching traffic. The Type I object marker shall consist of nine yellow prismatic reflectors, each with a minimum dimension of 3 inches, mounted symmetrically on a 18 inch black or yellow diamond panel; or a 18 inch yellow diamond panel of Type III reflective sheeting without buttons. The object marker shall be placed approximately 2 inches below the top of the first module.

10. Flashing Arrow Panel:

a. The Contractor shall furnish, install, and operate mounted flashing arrow panels for use in traffic control at the locations shown in the plans. The Contractor shall remove the panels when work is complete and the Engineer has approved their removal.

b. (1) The minimum panel size shall be 8 feet by 4 feet and shall contain 22 lamps. The lamps shall be arranged to form 3 connected diamonds with the short axis of the diamonds lying on the horizontal centerline of the sign. Each side of the diamonds will form an arrowhead of 5 lamps per head. Each arrowhead shall have a minimum angle of 100 degrees.

(2) The panel shall be constructed in a rigid manner such that the panel face does not flex in the vertical dimension.

(3) For use on multi-lane roadways where at least one traffic lane is maintained for each direction of travel, the arrow panel shall have the capability of the following mode selections:

(i) Left or right flashing arrow.

(ii) Left or right sequential chevrons.

(iii) Double flashing arrows.

(4) For use as a hazard identification marker on 2-lane highways with 1 lane closed, the flashing arrow panel shall be wired to alternately flash the two outside diamonds or flash the 4 outside corners.

(5) Minimum "on time" shall be 50 percent for the flashing arrow and flashing diamonds and equal intervals of 25 percent for each sequential phase.

c. (1) Lamps for generator powered arrow panels shall maintain visibility out to a horizontal angle of 20 degrees.

(2) Solar powered arrow panels shall maintain visibility out to a horizontal angle of 13 degrees.

(3) Vertical maintained visibility shall be greater than 3 degrees.

(4) The lamp intensity shall be adjusted to prevent an unnecessary blinding effect and to compensate for daytime and nighttime light conditions so that the arrow panel message is legible for a distance of 1 mile. The intensity shall be controlled by an automatic dimmer capable of a 50 percent reduction in intensity when ambient light falls below 5 foot candles.

d. (1) The arrow panel shall be aimed to provide for recognition throughout the range from 1,600 feet to 300 feet upstream of the panel.

(2) For use on 2-lane highways as a hazard identification marker, the mounted arrow panel shall be located immediately in front of the hazard and behind a Type III barricade.

(3) The arrow panel shall be mounted at a minimum height of 7 feet from the road surface to the bottom of the panel.

(4) The arrow panel shall be mounted such that it will remain stationary and rigid in high or gusty winds while the panel is in use.

e. (1) The arrow panel shall be maintained so as to operate continuously. The Contractor shall advise the Engineer of the person to contact in case of needed repairs or maintenance.

(2) The Contractor shall always have an extra unit on the project for use as a standby unit. In the event of equipment failure resulting in an arrow panel becoming inoperative, regardless of the time of day, the Contractor shall immediately substitute the standby unit for the inoperative arrow panel. The Contractor shall then either immediately repair or replace the defective unit.

11. Type B High Intensity Warning Lights:

a. Type B High Intensity Warning Lights shall be furnished, placed, operated, and maintained as shown in the plans.

b. When work is complete and their removal has been approved by the Engineer, the warning lights shall be removed by the Contractor.

12. Pilot Vehicle:

a. This work shall consist of providing a vehicle and driver to serve as a pilot vehicle to lead the traveling public and the Contractor's vehicles through the construction work area where 2-way traffic is restricted to only one lane.

b. (1) The pilot vehicle shall be properly equipped and licensed for operation on public roadways in accordance with the applicable State laws.

(2) The vehicle shall carry the Contractor's monogram or company insignia and shall be equipped with a rear facing, rigidly mounted sign having a fluorescent orange background with black lettering bearing the message:

"PILOT CAR---FOLLOW ME"

(3) The sign shall be a MUTCD sign No. G20-4, sized at 36 x 18 inches.

(4) The bottom of the sign shall be mounted a minimum of 1 foot above the vehicle's roof.

(5) The sign shall be securely covered or removed when not in use.

(6) The vehicle, while in use, shall be used exclusively to lead and assist traffic movement.

(7) During construction, a pilot vehicle shall be kept in continuous operation. Delays to traffic movement will not be allowed for refueling, driver relief, or any other foreseeable reason.

(8) The work shall be so coordinated that the pilot vehicle shall make a roundtrip in 15 minutes or less.

c. Pilot vehicle drivers shall be properly licensed and shall be familiar with and always observe the "Rules of the Road" for proper, safe, and courteous driving. Drivers will be subject to prosecution for all violations.

d. Pilot vehicle drivers shall be certified flaggers and must have their Flagger Certification Card in their possession at all times.

13. Tubular Post:

a. The Contractor shall furnish, install, maintain, and remove reflectorized tubular posts at the locations shown in the plans or as directed by the Engineer.

b. (1) The height of a tubular post shall be 28 inches. The material from which the post is fabricated shall be rubber, plastic, or any other material which meets the physical test requirements and results in little or not damage to impacting vehicles. The minimum width of the post shall be 2 inches. The predominant color of the post shall be orange.

(2) Each complete tubular post and each replacement post must have a minimum of two 3-inch wide reflective white bands placed a maximum of 2 inches from the top with a maximum of 6 inches between the bands. The reflective white bands must be 3M flexible high intensity grade reflective sheeting or approved equivalent.

(3) Tubular posts that are approved for use are shown in the NDR Approved Products List. Tubular posts which have not been previously approved by the Department will not be permitted on the project until approved by the Engineer.

c. (1) The tubular posts shall be spaced at the intervals shown in the plans or as directed by the Engineer and shall be attached to the existing surface by epoxy or other suitable adhesive. The adhesive shall be given adequate time to harden before the post can be attached and the area opened to traffic. The initial placement and/or replacement of the tubular posts shall be performed with extreme care and consideration for the traveling public.

(2) Reflective sheeting which is no longer effective shall be replaced.

(3) Tubular posts which have become dislodged due to traffic or other action shall be properly repositioned and reattached within 24 hours. Tubular posts which cannot be cleaned or which are broken shall be replaced.

d. Upon completion of that particular phase of the work requiring tubular post delineation, the Contractor shall remove the posts as directed by the Engineer. The Contractor shall exercise care and consideration for traffic control during removal, initial installation, and replacement. The Contractor must explain this phase of traffic control to the Engineer before installation, replacement, and removal.

14. Opposing Lane Dividers:

a. (1) The Contractor shall furnish, install, and maintain reflectorized opposing lane dividers at the locations shown in the plans.

(2) When work is complete and the Engineer has approved their removal, the Contractor shall remove the reflectorized opposing lane dividers.

b. (1) The height of the opposing lane divider shall be 36 inches.

(2) The divider shall be fabricated from rubber or plastic.

(3) The predominant color of the divider shall be orange.

c. Each opposing lane divider and each replacement divider must have back-to-back, upright, orange, reflective panels approximately 12 inches wide by 18 inches high. The symbol on the divider shall be 2 opposing black arrows. The reflective panel must be AASHTO M 268 Type III reflective sheeting or approved equivalent.

d. (1) The opposing lane dividers shall be attached to the existing surface by an epoxy or other approved adhesive.

(2) The adhesive shall be given adequate time to harden before the divider can be attached and the road opened to traffic.

e. (1) Reflective panels which are no longer effective shall be replaced.

(2) Lane dividers which cannot be cleaned or which are broken shall be replaced.

15. Pavement Marking Removal:

The Contractor shall remove conflicting permanent (not "temporary") pavement markings as shown in the plans or as required by the Engineer.

16. Temporary Glare Screen:

a. The Contractor shall furnish, install, maintain, and remove temporary glare screens (TGS) on Department-furnished concrete protection barriers at the locations shown in the plans.

b. The TGSs shall be installed as required by the manufacturer. The anchors shall be flush mounted. The TGSs shall consist of a white base rail (10 feet length) and green blades (2 foot height) angled at 0.384 radians. Every 10 feet, a 2 x 12 inch vertical, yellow, high intensity AASHTO M 268 Type III reflective sheet shall be placed at the midpoint on the right side of the vertical blade, one for each direction of travel.

c. Before installing the TGS, the Contractor shall furnish and install the internally threaded sleeve into the protection barrier. The top of the sleeve shall be flush with the top of the barrier.

d. Damaged sheeting, blades, base rails, and blades which no longer provide glare protection (such as bent blades or blades which move significantly in the wind) shall be immediately repaired or replaced by the Contractor at no additional cost to the Department.

e. Upon completion of the project, the Contractor shall remove the temporary glare screens (base rail and blades). The anchor sleeves in the concrete barriers shall be plugged with weatherproof plugs provided by the manufacturer. The plugs become the property of the State.

17. Changeable Message Signs:

The Contractor shall furnish, install, operate, and maintain changeable message signs as prescribed in the plans. When their removal is approved by the Engineer, the Contractor shall remove the changeable message signs.

18. Install Impact Attenuator:

a. (1) The Contractor shall pick up the impact attenuator from the location designated by the Engineer and assemble the attenuator in accordance with the details shown in the plans. The Contractor shall transport, maintain, and install the units at the location shown in the plans or designated by the Engineer.

(2) A second unit shall be stored with replacement cartridge sets in the Lincoln Maintenance Yard. It will be available in the event of damage to the installed system or if a second system is required while the original system is still in operation.

b. The Contractor shall perform all earthwork and provide the reinforced concrete pad (required for off-the-road installations) needed to place the unit. The Contractor shall immediately repair or replace any damaged units.

c. Upon completion of the pavement work on an initial construction phase, the Contractor will be required to relocate the attenuator to the position required for the traffic protection for pavement work on the subsequent phases.

d. Upon completion of the work, the Contractor shall dissemble the system and return it to the location designated by the Engineer.

422.04 -- Method of Measurement

1. a. (1) "Sign Days" is the pay item for permanent signs and permanent signs and permanent sign days shall be measured by the each. Signs must be installed in accordance with the plans or as directed by the Engineer.

(2) "Temporary Sign Days" is the pay item for "Temporary Signs" and "Temporary Sign Days" shall be measured by the each. Signs must be installed in accordance with the plans or as directed by the Engineer.

b. The quantity of sign days shall be the number of signs multiplied by the number of calendar days that the respective signs are in place.

c. A calendar day for signs shall be defined as the 24-hour period from midnight to midnight, or any portion of it, within which the sign is installed and maintained.

d. Each sign shall be paid for separately, even if more than one sign is installed on the same post or device.

2. a. Type III barricades shall be measured for payment by the number of calendar days each Type III barricade is in place and positioned as shown in the plans or as directed by the Engineer. The unit is barricade-day (BDay).

b. (i) "Type II Barricades, Reflectorized Drums, 42" (1070 mm) Reflective Cones, and Vertical Panels shall be measured for payment by the number of calendar days each is in place and positioned as shown in the plans or as directed by the Engineer. Payment shall be made at the established contract unit price.

(ii) Vertical panels will be paid at ½ the contract unit price for "Barricade Type II".

(iii) Reflectorized Drums and 42" (1070 mm) reflective cones are paid at the unit price for "Barricade Type II:

c. Payment for "Barricades, Type II", "Barricades, Type III", 42" (1070 mm) Reflective Cones and Vertical Panels will not be made for any devices which are not kept clean and properly positioned.

d. Payment for any traffic control device paid for by the day (excluding "Flagging") will not extend beyond the last working day or calendar day allowed by the contract. Payment will be made for any approved extension of the contract time allowance. The traffic control devices paid by the day that are required as determined by the Project Manager, shall remain in service at no cost to the Department.

3. a. "Flagging" will be measured for payment for each flagger location on a daily basis.

b. Operation of one flagger for 4 hours or less will be considered as one-half day and operation for more than 4 hours will be considered as one full day.

c. This price shall be full compensation for furnishing properly trained, attired, and equipped flaggers, for furnishing, installing, maintaining, and removing up to eight temporary signs per flagger situation as directed by the Engineer, and for all labor, tools, equipment, material, and incidentals necessary to complete the work. Temporary signs and stands for flaggers shall comply with the requirements of Temporary Sign.

4. a. "Temporary Traffic Signal" is measured by the each for every complete installation.

b. When a traffic signal is required at a bridge or other obstruction, all signals required to clear traffic through the obstruction are counted as a single unit.

5. a. "Concrete Protection Barrier" is measured by the length in feet (meters) based on the 10 foot (3 m) nominal length of the individual units.

b. The pay item "Relocate Concrete Protection Barrier" applies to those repositionings directed by the Engineer or shown in the plans, and these relocations shall be measured by the length of the concrete barriers so relocated based on the 10 foot (3 m) nominal length of the individual units.

6. a. (1) "Temporary Pavement Markings _____" and "Temporary Pavement Marking" shall be measured by the linear feet (meter) of each line applied.

(2) All gaps are not measured.

b. (1) "Overlay Solid Lines" and "Overlay Broken Lines" are measured by the station.

(2) Measurements can be made from the estimated length of each segment.

(3) When necessary, measurements shall be along the centerline or edgeline, as appropriate, between the beginning and ending points of the project and between the beginning and ending points of any intersecting roadway, shoofly, detour, or ramp.

(4) Breaks or gaps that are not part of a standard pattern (such as identified in Tables 422.01 and 422.02.) and which are more than 100 feet (30 m) in length are not measured for payment.

(5) Breaks or gaps that are part of a standard pattern in “Overlay Broken Lines” are measured.

c. Arrows, words, and symbols shall be measured by the each. Arrows shall be counted by each head.

d. Excluded from payment are any applications for maintenance of previously applied lines, replacement of previously applied lines that have worn or were covered by asphalt or any other substance and applications that are necessary to accommodate the Contractors schedule; as prescribed in Paragraph 9. of Subsection 422.05 of these applications are subsidiary.

e. Replacement of all temporary lines necessary because of required daily maintenance or the Contractor’s work quality or schedule of operation shall not be measured for payment and is subsidiary to the relevant pay item.

f. When traffic must be routed over a new application of asphalt and the traffic is directed over payment markings, then the Department will pay to replace the markings that have been removed by traffic.

7. a. Raised pavement markers are measured by the linear foot.

b. When the spacing between the raised pavement markers is 10 feet or less, the length to be paid for shall be the distance between the first and last markers measured along the path represented by the markers.

c. When the spacing between raised pavement markers is greater than 10 feet, the distance shall be considered a gap and shall not be measured for payment.

d. All other marking materials shall be measured by the actual length of line installed, excluding gaps.

8. Temporary rumble strips will be measured for payment by the each for the entire section of temporary rumble strips initially installed at a specific location. No direct payment will be made for rumble strips replaced.

9. a. The inertial barrier system shall be measured by the each.

b. The replacement modules for the inertial barrier system shall be measured for payment by the each for each module installed on the project.

10. a. Flashing arrow panels are measured by the each per each calendar day in use.

b. A double-faced flashing arrow panel will be counted as two units when a double-faced panel is prescribed in the plans.

11. Type B High Intensity Warning Lights shall be measured by the each per day for the number of calendar days each Type B light is in place and operating. The unit is light-day (LDay).

12. “Pavement Marking Removal” shall be measured by the linear foot along the centerline of the traveled roadway for each permanent (not “temporary”) line removed.

13. The pilot vehicle will be measured for payment on a daily basis when actually in use. Operation for 4 hours or less shall be considered as one-half day and operation for more than 4 hours shall be considered as a full day.

14. Tubular posts are measured by the each.

15. Opposing lane dividers are measured by the each.

16. Temporary Glare Screen is measured by the length in linear feet of base rail initially installed, complete with blades.

17. Changeable message signs are measured by the each per day for the number of calendar days each sign is in place and operating.

18. "Install Impact Attenuator" is measured by the each.

19. a. “Replacement Module” is the pay item for inertial barrier system replacement modules and the unit of measurement is each (EA).

b. “Relocate Inertial Barrier” is the pay item for moving the inertial barrier to a new location after initial installation and operation.

20. a. “Remove Pavement Marking” is paid by the linear feet (meter) of temporary or permanent pavement marking removed.

b. Gaps are excluded from measurement. This includes gaps in standard patterns of “Broken Lines.”

c. Removal of pavement markings is only paid when the marking alignment is different from an existing permanent marking or if an alignment is changed after a temporary marking is placed and the new alignment does not cover the temporary alignment.

422.05 -- Basis of Payment

1.

Pay Item	**Pay Unit**
Sign Day	Each (ea)
Barricade, Type II	Barricade-Day (BDay)
Barricade, Type III	Barricade-Day (BDay)
Flagging	Day (d)
Temporary Traffic Signal	Each (ea)
Install Concrete Construction Barrier	Linear Foot (LF)
Concrete Protection Barrier	Linear Foot (LF)
Temporary Pavement Marking, Type ___	Linear Foot (LF)
Raised Pavement Marker	Linear Foot (LF)
Temporary Rumble Strip	Each (ea)
Inertial Barrier System	Each (ea)
Flashing Arrow Panel	Day (d)
Type B High Intensity Warning Light	Light-Day (LDay)
Pavement Marking Removal	Linear Foot (LF)
Furnishing & Operating Pilot Vehicle	Day (d)
Opposing Lane Divider	Each (ea)

Temporary Glare Screen	Linear Foot (LF)
Changeable Message Sign	Day (d)
Tubular Post	Each (ea)
Install Impact Attenuator	Each (ea)
Temporary Sign Day	Each (ea)
Overlay Broken Lines	Station (Sta) [Station (StaM)]
Overlay Solid Lines	Station (Sta) [Station (StaM)]
Remove Pavement Marking	Linear Feet (LF) [Meter (m)]
Relocate Inertial Barrier	Each
Replacement Module	Each
Relocate Concrete Protection Barrier	Linear Feet (LF) [Meter (m)]
Temporary Pavement Marking	Linear Feet (LF) [Meter (m)]
____ Temporary Pavement Marking Type ____	Each (ea)

2. a. If signs are not returned, the Contractor shall be charged the value of the missing items. These charges shall be deducted from monies due the Contractor upon final payment.

b. Payment will not be made for those calendar days when signs are not in use, such as for folded signs, temporarily covered signs, or signs temporarily positioned so that the message is not readable by the travelling public.

c. (1) Temporary Signs which are required for “Flagging” are subsidiary to “Flagging”.

(2) The “Temporary Sign” pay item shall be full compensation for furnishing the “Temporary Sign” and for “Temporary Sign” support, transportation, original installation, any required relocation and maintenance of any and all “Temporary Signs”, for removal of all “Temporary Signs”, and for all equipment, tools, labor, and incidentals necessary to complete the work.

3. a. The pay item “Barricades, Type II” is used to pay for four (4) items (Vertical Panels, 42 inch (1070 mm) Reflectorized Cones, Reflectorized Drums, & Barricades, Type II).

b. Vertical Panels shall be paid for at 1/2 the contract unit price established for the item, “Barricades, Type II”.

c. “42 inch (1070 mm) Reflectorized Cones”, “Reflectorized Drums” and “Barricades, Type II” shall be paid for at the contract unit price established for the item, “Barricades, Type II”.

4. Barricades, Type II are paid for as an "established" contract unit price item, which is shown in the bid proposal "Schedule of Items".

5. a. The Contractor shall be responsible for the utility costs to install or relocate the power service for temporary traffic signals.

b. The Contractor shall also pay for power to operate the temporary signals. However, costs for power to operate a temporary signal that replaces an existing operating signal shall be paid by the jurisdiction responsible for the power costs of the permanent signal.

c. Direct payment will not be made for power costs. Power costs shall be considered subsidiary to the temporary traffic signal.

6. Except for Type B High Intensity Warning Lights, all warning lights shall not be measured for payment but shall be considered subsidiary to the items for which direct payments are provided.

7. No direct payment will be made for opposing lane dividers repositioned, reattached, or replaced or for their removal.

8. The repositioning and/or reattachment, removal, and/or replacement of a tubular post is subsidiary to the pay item "Tubular Post."

9. a. Maintenance of temporary pavement markings is subsidiary to the appropriate pay item. Maintenance includes replacement of lines worn by traffic or covered by asphalt or any other substance. The Engineer will determine when the lines are no longer effective and direct the Contractor to replace the lines at no additional cost to the Department.

b. Replacement of, temporary markings which is necessary because of the Contractors schedule of operation or the Contractor's work quality is subsidiary to the relevant pay item.

c. Temporary marking removal (broken and solid lines; raised pavement markers; and arrows, words, symbols) is subsidiary to the relevant pay item.

d. Overlay markers shall be subsidiary to the relevant temporary pavement marking pay item.

e. Sandblasting to remove the curing compound from the pavement surface before placing pavement markings shall be considered subsidiary to the relevant temporary pavement marking pay item.

10. a. Payment for inertial barrier systems and replacement modules shall include all modules required to build and maintain the required array of barrels, sand filler material, salt, object markers, installation, maintenance, earthwork required for placing the system on flat ground, removal of the system, and cleaning of the site.

b. "Relocation Inertial Barrier" is paid for each relocation.

11. The pay item "Temporary Pavement Marking" includes the following material options:

- Temporary Pavement Marking, Type I (Tape)
- Temporary Pavement Marking, Type II (Tape)
- Temporary Pavement Marking, Type Paint
- Temporary Pavement Marking, Type RPM

12. "_____Temporary Pavement Marking Type_____" is the pay item for arrows, words, and symbols.

13. Removal of markings is subsidiary to all temporary pavement marking and overlay marking except:

a. If the Department denies the Contractor the opportunity to apply his own temporary paint and then applies its own paint (the Department), then the Contractor is entitled to reimbursement for removing the Department's paint.

b. The Contractor shall match the existing pattern when an area must be restriped.

c. If the markings must be placed at a new alignment, then existing pavement markings shall be removed. The removal will be a separate pay item, "Remove Pavement Marking."

14. Marking material specified in the plans or other contract documents should not be changed to a less expensive material (usually paint) without a change order.

15. Payment is full compensation for all work prescribed in this Section.

SECTION 423 -- TRAFFIC PROVISIONS

This entire Section 423 is void and deleted.

SECTION 424 -- PERMANENT PAVEMENT MARKING

424.01 -- Description

This work shall consist of furnishing and installing retroreflective preformed pavement markings in accordance with these *Specifications* and in reasonably close conformance to the dimensions and lines shown in the plans or established by the Engineer. This specification covers the following permanent pavement marking materials and application methods:

1. Durable Retroreflective Preformed Pavement Marking, Type I (60 mil thickness).

2. Durable Retroreflective Preformed Pavement Marking, Type II (preformed marking film).

3. Durable Retroreflective Preformed Pavement Marking, Type III (intersection grade).

4. Durable Retroreflective Preformed Patterned Pavement Marking, Type IV (with improved retroreflectivity retension).

5. Thermoplastic Pavement Marking.

6. Thermoplastic Pavement Marking, Type Spray.

7. Epoxy Pavement Marking.

8. Preformed Pavement Marking Tape, Type IV in Grooved Pavement.

9. Permanent Pavement Marking, Paint and Beads.

424.02 -- Material Requirements

1. Acceptable Durable Retroreflective Preformed Pavement Marking, Types I, II, III, and IV shall be on the NDR Approved Products List.

2. Thermoplastic Pavement Marking Materials:

a. The composition minimum percentages by weight are shown in Table 424.01.

Table 424.01

Minimum Composition Requirements		
	White Minimum Percentage	**Yellow Minimum Percentage**
Binder	18	18
TiO_2 (Type 2 Rutile)	8	N/A
Glass Spheres	35	35
Yellow Pigment	N/A	5.0

b. The alkyd binder shall consist of maleic modified medium lead chromate pigment with a minimum of 50 percent lead-free content.

c. The alkyd binder shall consist of maleic modified rosin ester and not more than 20 percent petroleum derived resin.

d. The yellow pigment used shall be a heat established medium lead pigment with zero percent lead content.

e. Physical Requirements:

(1) Color:

(i) The white thermoplastic shall be pure white and free from any tint. When tested with a Colorimeter, such as a Gardner Color Difference Meter, the material shall not show deviations from a magnesium oxide color standard that are greater than shown in Table 424.02.

Table 424.02

Color Deviations		
	Magnesium Oxide	
Scale Definitions	**Standard**	**Sample**
RD Reflectance	100	75% Min.
a Redness-Greeness	0	-5 to +5
b Yellowness-Blueness	0	-10 to +10

(ii) The color of the yellow thermoplastic shall visually match that of FHWA PR Color #1 when tested in accordance with ASTM D 4960. The daytime reflectance values and chromaticity coordinates shall fall within the limits in Table 424.03.

Table 424.03

Reflectance and Chromaticity				
Reflectance	45% Min.			
Chromaticity	Shall fall in an area bounded by these coordinates:			
	x - 0.470	0.493	0.516	0.490
Coordinates x, y	y - 0.455	0.467	0.444	0.433

f. Color Retention:

(1) The thermoplastic materials shall maintain the color values specified herein for white and yellow after the samples are prepared and subjected to an ultraviolet light source as described in ASTM D 795.

Note: A General Electric 275 watt sun lamp (Type RS) with a built-in reflector may be substituted for the light source.

g. Water Absorption:

The thermoplastic compound shall have no more than 0.5 percent by weight of retained water when tested in accordance with ASTM D 570.

h. Softening Point:

The compound shall have a softening point of not less than 195°F, as determined by ASTM E 28.

i. Low Temperature Stress Resistance:

A concrete substrate coated with a minimum of 32 square inches of thermoplastic material shall be immersed in cold water for one hour; then immediately placed in an insulated cold compartment and maintained at a temperature of minus 50°F for a period of 24 hours. When removed and allowed to come to room temperature, the sample shall still adhere to the contract substrate with no cracking or flaking.

j. Reheating:

The thermoplastic compound shall maintain proper performance properties when heated 4 times to the application temperature. After heating to 425°F for 6 hours while continually stirring at 50 to 100 RPM, the Brookfield viscosity shall not exceed 16,000 cps at 12 RPM.

k. Safety:

In the plastic state, the material shall not give off fumes which are toxic or otherwise injurious to persons or property.

l. Specific Gravity:

The specific gravity of the compound as determined by the water-displacement method shall be between 1.9 and 2.5.

m. Drying Time:

When the material is applied at 400°F, the line shall be completely solid and show no effect of tracking after 15 minutes.

n. Indentation Resistance:

The hardness shall be measured by a Shore Durometer, Type A-2, as described in ASTM D 2240. The durometer and the panel shall be at least 110°F. With a 4.4 pound load applied, the reading shall not be less than 45 after 15 seconds.

o. Abrasion Resistance:

The sample shall show a maximum loss of 0.0132 pound when tested by the blasting box method.

p. Impact Resistance:

The average impact resistance of 4 separate samples shall not be less than 10.0 inches/pounds when tested according to Method A of ASTM D 256.

q. Sealing Primer:

The particular type and the proportions used shall be as recommended by the manufacturer of the thermoplastic compound.

r. Glass Spheres:

(1) Refractive Index:

The reflective glass spheres pre-mixed into the compound and the reflective glass spheres used for surface application shall have a refractive index of not less than 1.50 when tested by the liquid emersion method at 75°F.

(2) Roundness:

Not less than 75 percent of the beads overall and not less than 70 percent of the beads retained on any specified sieve shall be true spheres when tested by ASTM D 1500.

s. Coatings:

The intermix and drop-on beads shall have an adhesion promoting coating which is specific for the thermoplastic system. The beads for surface application shall be resistant to clumping caused by moisture.

t. Flowing Properties:

(1) The glass beads shall flow uniformly through dispensing equipment in atmospheric humidity up to 94 percent.

(2) 0.22 pounds of glass beads, spread evenly and thinly in a suitable container, shall be conditioned at 75°F for 4 hours over a solution of sulfuric acid (Sp. Gr. 1.10) in a closed desiccator. After 4 hours, the glass beads shall flow readily through a clean glass analytical funnel, 60 degrees, 0.20 inch diameter and 4 inch stem. Inside diameter of the stem shall be a nominal 1.4 inches.

u. Adhesion Coating:

The glass beads shall be coated with an adhesion promoting coating that is compatible with thermoplastic material and that passes the dansyl chloride test procedure.

v. Gradation:

(1) The intermixed and surface applied glass beads shall meet the gradation requirement in Table 424.04.

Table 424.04

Glass Bead Gradation	
Sieve Size	**Percent Passing**
No. 16	100
No. 20	75-95
No. 30	20-40
No. 50	0-5
No. 100	0-2

(2) The surface application of beads shall be not less than 12 lb/100 SF.

(3) Properties of Finished Striping and Marking Installation:

(i) The stripe shall not be slippery when wet.

(ii) The compound shall not lift from the pavement in freezing weather.

(iii) The compound shall not deteriorate by contact with sodium chloride, calcium chloride, or oil drippings from traffic.

(iv) After application and proper drying time, the stripe shall show no appreciable deformation or discoloration under traffic at temperatures up to 140°F.

(v) The stripe or marking shall maintain its original dimensions and placement. The exposed surface shall be free from tack. Cold ductility of the material shall be such as to permit normal movement with the road surface without chipping.

w. The Contractor shall field verify the pavement marking quantities required for the project prior to purchasing material. The Department will not be responsible for the Contractor's shortage or surplus of material.

3. Hot Spray Thermoplastic Pavement Marking Material:

a. Binder:

The binder shall consist of a mixture of synthetic alkyd resins, at least one of which is solid at room temperature. The total binder content of the thermoplastic compound shall be well distributed through the compound. The binder shall be free from all foreign objects or ingredients that would cause bleeding, staining or discoloration. The binder shall be at least 25 percent by weight of the thermoplastic compound.

b. Pigment:

(1) White. The pigment used for the white thermoplastic compound shall be a high-grade pure (minimum 93 percent) titanium dioxide (TiO_2). The white pigment content shall not be less than 10 percent by weight and shall be uniformly distributed throughout the thermoplastic compound.

(2) Yellow. The pigments for the yellow thermoplastic compound shall be heat stabilized medium lead chromate pigment with a minimum of 50 percent lead-free content. The yellow pigment shall not be less than 5 percent by weight and shall be uniformly distributed throughout the thermoplastic compound.

c. Filler:

The filler to be incorporated with the resins as a binder shall be a white calcium carbonate, silica, or an approved substitute. Any filler which is insoluble in 5N hydrochloric acid shall be of such particle size as to pass a No. 100 sieve.

d. Mixed Compound:

The mixed thermoplastic compound, after heating for 4 hours ± 5 minutes at 375° ± 3°F and cooled at 77°F, shall meet the following requirements for daylight reflectance and color when tested using a color spectrophotometer with 45 degree circumferential, 0 degree geometry, illuminant C, and 2 degree

observer angle. The color instrument shall measure the visible spectrum from 380 to 721 nm with a wavelength measurement interval and spectral bandpass of 10 nm. Reflectance and chromaticity limits are shown below.

Reflectance and Chromaticity Limits				
White: Daylight Reflectance (Y) 75 percent minimum				
* Yellow: Daylight Reflectance (Y) 42-59 percent				
* Shall match Federal 595 Color No. 33538 and chromaticity limits as follows:				
	X	.470	.510	.485	.530
	Y	.455	.485	.452	.456

e. Specific Gravity:

The specific gravity of the thermoplastic material shall not exceed 1.85.

f. Softening Point:

After heating the thermoplastic material for 4 hours ± 5 minutes at 375° ± 3°F and testing in accordance with ASTM E 28, the material shall have a minimum softening point of 180°F as measured by the ring and ball method.

g. Tensile Bond Strength:

After heating the thermoplastic material for 4 hours ± 5 minutes at 375°F, the drawdown film thickness shall be 0.065 inch; and when tested at 75° ± 2°F in accordance with ASTM D 4796, the tensile bond strength to unprimed, sandblasted portland cement block shall exceed 180 psi.

h. Impact Resistance:

The thermoplastic material is heated for a period of 4 hours at a temperature of 375°F. A 0.065 inch thick drawdown film shall be created on an unprimed, sandblasted portland cement concrete block. Allow the sample to reach room temperature by standing overnight. Using a suitable falling ball apparatus that includes the male indentor 5/8 inch (no female die), impact the sample and observe for any cracking or loss of bond. When tested in accordance with ASTM D 2794, the material shall have a minimum impact resistance of 150 inch pounds with no visible cracks or loss of bond.

i. Yellowness Index:

The white thermoplastic material shall not exceed a yellowness index of 12 when tested in accordance with ASTM D 1925.

j. Packaging:

(1) The thermoplastic material shall be packaged in suitable containers which will not adhere to the product during shipment and storage. The container's weight shall be approximately 50 pounds. Each container shall designate the color, type of binder, spray, and user information. The label shall warn the user that the material shall be heated in the range of 350 to 425°F.

(2) Each package shall be marked with the name of the manufacturer, the type of material, the month and year the material was packaged, and the lot number.

k. Glass Beads:

(1) Intermix Beads:

(i) Intermix beads shall be uncoated and shall be uniformly sized throughout the thermoplastic material at the rate of not less than 35 percent by weight (retained on the No. 100 sieve) of the thermoplastic material.

(ii) Intermix beads shall meet the gradation requirements in Table 424.05.

Table 424.05

Intermix Bead Gradation	
Sieve Size	**Percent Passing**
No. 20	100
No. 30	75-95
No. 50	15-35
No. 100	0-5

(2) Drop-on Beads:

(i) Drop-on beads shall be moisture resistant, imbedment coated, and shall consist essentially of transparent, water-white glass particles of a spherical shape. They shall be manufactured from a glass of a composition designed to be highly resistant to traffic wear and to the effects of weathering and shall conform to the requirements specified herein.

(ii) Drop-on beads shall meet the gradation requirements in Table 424.06.

Table 424.06

Drop-On Bead Gradation	
Sieve Size	**Percent Passing**
No. 16	100
No. 20	75-95
No. 30	20-40
No. 50	0-5
No. 100	0-2

l. Specific Properties of Intermix and Drop-on Beads:

(1) Imperfections. The surface of the glass beads shall be free of pits and scratches. The glass beads shall be spherical in shape and shall contain not more than 20 percent by weight of irregular shapes when tested by the standard method using a vibratile inclined glass plate.

(2) Index of Refraction. The index of refraction of the glass bead shall be not less than 1.50 when tested by the immersion method at 77°F.

(3) Silica Content. The glass bead shall contain not less than 65 percent silica ($Si0_2$).

(4) Chemical Stability. Glass beads which show a tendency toward decomposition, including surface etching, when exposed to paint or thermoplastic constituents will be rejected. The glass beads shall be tested by Federal Specification T-T-B-1325A, Section 4.3.11 (water resistant soxhlet extraction method), with the following exceptions:

(i) Under "Procedure", the size of sample to be tested shall be 1 ounce.

(ii) Under "Testing", Paragraph (1), the reflux item shall be 5 hours and, upon examination after testing, the glass beads shall show no dulling effect.

(iii) Under Paragraph (2), use of more than 0.15 fluid ounce of 0.1N hydrochloric acid to reach the end point shall constitute failure of the test.

(5) Flowing Properties:

(i) The glass beads shall flow uniformly through dispensing equipment in atmospheric humidity up to 94 percent.

(ii) 0.22 pound of glass beads, spread evenly and thinly in a suitable container, shall be conditioned at 77°F for 4 hours over a solution of sulfuric acid (Sp. Gr. 1.10) in a closed desiccator. After 4 hours, the glass beads shall flow readily through a clean glass analytical funnel, 60 degrees, 0.20 inch diameter and 4 inch stem. The inside diameter of the stem shall be a nominal 1.4 inch.

(6) Adhesion Coating. The glass beads shall be coated with an adhesion promoting coating that is compatible with thermoplastic material and that passes the manufacturer's adhesion test.

(7) Packaging. Glass beads shall be delivered in approved, moisture-proof bags consisting of at least 5-ply paper construction. Each bag shall contain 50 pounds net, and shall be legibly marked with the name of the manufacturer, type of bead, lot number, and the month and year the glass beads were packaged.

4. Epoxy Pavement Marking

a. Glass Beads

(1) Glass beads for epoxy pavement marking shall conform to AASHTO M 247, Type I and Type IV, except that they shall be coated as required by the epoxy manufacturer. The glass beads shall have a minimum of 80 percent rounds per screen for the two highest sieve quantities (determined visually) and no more than 3 percent angular particles per screen (visual). The remaining sieve fractions shall be no less than 75 percent rounds (determined visually per aspect ratio using microfiche reader). Type IV only is 70 percent by roundometer overall (ASTM D 1155). Angulars will be determined visually for

Type IV at 3 percent overall. (Angulars are defined as particles with sharp edges).

(2) The glass beads shall have a refractive index of 1.50 to 1.52.

(3) Sieve Size

Type 1		Type 4	
English Sieve No. (Metric)	**% Passing**	**English Sieve No. (Metric)**	**% Passing**
20 (850 µm)	95 - 100	10 (2.00 mm)	100
30 (600 µm)	80 - 95	12 (1.70 mm)	95 - 100
50 (300 µm)	9 - 42	14 (1.40 mm)	80 - 95
80 (180 µm)	0 - 10	16 (1.18 mm)	10 - 40
100 (150 µm)	-	18 (1.00 mm)	0 - 5
		20 (850 µm)	0 - 2

(4) Glass beads shall be furnished in fully identified containers and shall be free of extraneous material or clumps.

b. Formulation

(1) Epoxy pavement marking material shall be a two component, 100 percent solids, material formulated to provide simple volumetric mixing ratio of two volumes of component A and one volume of component B unless otherwise recommended by the material manufacturer.

c. Composition

(1) The component A of both white and yellow shall be within the following limits:

Pigments	White	Yellow	Non-Lead Yellow
Titanium Dioxide (ASTM D 476 Type II & III)	18-25%		14-17%
Chrome Yellow (ASTM D 211 Type III)		23-30%	
Organic Yellow			7% Min.

d. Binder

Epoxy Resin	75-82%	70-77%	80-85%

e. Epoxy Content

(1) The epoxy content of the epoxy resin in Part A will be tested in accordance with ASTM D 1652 and calculated as the weight per epoxy equivalent (WPE) for both white and yellow. The epoxy content will be determined on a pigment free basis. The epoxy content shall meet a target value provided by the manufacturer. A ± 75 tolerance will be applied to the target value to establish the acceptance range.

f. Amine Value

(1) The amine value of Part B shall be tested in accordance with ASTM D 2074 to determine its total amine value. The total amine value shall meet a target value provided by the manufacturer. A ±75 tolerance will be applied to the target value to establish the acceptance range.

g. Toxicity

(1) Upon heating to application temperature, the material shall not produce fumes which are toxic or injurious to persons or property.

h. Yellowness Index (ASTM D 1925)

Cure 72 hours after sample preparation
Take yellow index reading, XYZ C/2 deg., following
72-hour cure and preceding QUV
Maximum index before QUV: 5
Place sample in QUV for 72 hours
Maximum index after QUV: 20

i. Directional Reflectance (ASTM E-97)

j. Directional Reflectance after QUV using XYZ Scale D65/10 deg. using ASTM E-97.

White	Yellow
Minimum: 75	Minimum: 38

k. Drying Time

(1) The epoxy pavement marking material, when mixed in the proper ratio and applied at 20 mils ± 0.5 (510 µm ± 12 µm) mil wet film thickness at 75°F ± 2 F (24±1°C) and with the proper saturation of glass spheres, shall exhibit no tracking when tested according to ASTM D 711 8 minutes after application, when installed on an active roadway; or 30 minutes after application when installed on a closed roadway.

l. Curing

(1) The epoxy material shall be capable of fully curing under the constant surface temperature condition of 32 degrees F (0° C) and above.

m. Adhesion to Concrete

(1) The catalyzed epoxy pavement marking material, when tested according to ACI Method 503, shall have such a high degree of adhesion to the specified (4,000 psi (28 MPa) minimum) concrete surface that there shall be a 100 percent concrete failure in the performance of this test. Samples shall be allowed to cure at room temperature (75° F ± 2°F [24±1°C]) for a minimum of 24 hours and a maximum of 72 hours prior to performing the indicated test.

n. Hardness

(1) The epoxy pavement marking materials, when tested according to ASTM D 2240, shall have a Shore D Hardness over 80. Samples

shall be allowed to cure at room temperature (75 degrees F ± 2 degrees F [24±1°C]) for a minimum of 24 hours and a maximum of 72 hours prior to performing the indicated test.

o. Abrasion Resistance

(1) The abrasion resistance shall be evaluated, according to ASTM D 4060, on a Taber Abrader with a 1000 gram (2.2 lb.) load and CS-17 wheels. The duration of the test shall be 1000 cycles. The wear index shall be calculated based on ASTM test method C 501 and the wear index for the catalyzed material shall not be more than 70. The tests shall be run on cured samples of material which have been applied at film thickness of 15 ± 1/2 mils (380 µm ±13 µm) mils to code S-16 stainless steel plates (to be run without glass spheres). The samples shall be allowed to cure at 75° F ± 2° F (24±1°C) for a minimum of 24 hours and a maximum of 72 hours prior to performing the indicated tests.

p. Tensile Strength

(1) When tested according to ASTM D 638, the epoxy pavement marking materials shall have a tensile strength of not less than 6,000 psi (41 MPa). The Type IV Specimens shall be cast in a suitable mold and pulled at the rate of 1/4 inch (6.4 mm) per minute by a suitable dynamic testing machine. The samples shall be allowed to cure at room temperature (75°F± 2°F) [24+1°C] for a minimum of 24 hours and a maximum of 72 hours prior to performing the indicated test.

q. Compressive Strength

(1) When tested according to ASTM D 695, the catalyzed epoxy pavement marking materials shall have a compressive strength of not less that 12,000 psi (80 MPa). The cast sample shall be conditioned at room temperature (75 degrees F ± 2 degrees F) (24±1°C) for a minimum of 72 hours prior to performing the test. The rate of compression of these samples shall be no more than 1/4 inch (6.4 mm) per minute.

r. Certification of Compliance

(1) The Contractor shall furnish a manufacturer's certification that the material complies with the provisions of this specification.

5. The pavement marking tape shall be Preformed Pavement Marking, Type 4, when tape is in grooved pavement.

6. Permanent Pavement Marking Paint and Beads

a. The paint meeting the requirements of AASHTO M-248 shall be a commercially available VOC compliant, lead and chromium-free traffic paint, capable of receiving and holding glass beads for producing reflectorized traffic markings. The Contractor shall use a type of traffic paint that can be applied under the temperature conditions existing at the time of application. The paint shall be furnished ready mixed and shall not be diluted or thinned. The paint shall be compatible with drop-on floating conventional beads. The color for white paint after drying shall be a flat white, free from tint, furnishing good

opacity and visibility. For yellow, the color shall closely match Color Chip 33538 of Federal Standard 595.

b. The glass beads shall be AASHTO M-247 Type I, Flotation. The beads shall be free from clumps and suitable for application to the type of paint selected by the Contractor. The glass beads shall show good adherence to the paint binders and provide good night visibility throughout the useful life of the reflectorized binders. The beads shall allow sufficient capillary action to form a firm embedment in typical traffic paint when dropped on a freshly applied paint film. The beads shall contain recycled glass. A minimum of 90 percent by weight of the beads shall float on xylol and a minimum of 75 percent by weight shall float on normal heptane. The beads shall be accepted based on certified test results indicating that the beads meet the Specifications for AASHTO M-247 Type I, Flotation beads and the above requirements.

7. Performance Life/Acceptance.

All permanent pavement markings shall have the following acceptance requirements:

a. Following initial completion of all pavement marking, there will be a 180 day observation period before final acceptance. During the observation period, the Contractor, at no additional cost to the Department, shall replace any markings that the Engineer determines are not performing satisfactorily due to defective materials, workmanship in manufacture, or application. At the end of the observation period, the minimum required retention percentage, by area, for markings installed will be 95 percent.

b. Determination of Percentage Retained:

The percentage retained shall be calculated as the nominal area of the strip less the area of loss divided by the nominal area and expressed as a percentage of the nominal area.

c. (1) The Contractor shall be notified in writing within 30 calendar days after the 180 day observation period if there is a failure to achieve the required percentage retained.

(2) When such a notification is made prior to September 1, the replacement material shall be installed during the same construction season. Replacement materials for any notification after September 1 shall be installed prior to June 1 of the following year. Marking replacement shall be performed in accordance with the requirements specified herein for the initial application, including but not limited to surface cleaning, primer applications, etc.

d. Final acceptance of all markings will include an inspection of the appearance of the markings during daylight and darkness. Any markings that fail to have a satisfactory appearance during either period, as determined by the Engineer, shall be reapplied at no additional cost to the Department.

e. Final acceptance of the pavement marking will be:

(1) 180 days after the initial completion of all pavement marking work, or

(2) Upon completion of all corrective work, whichever occurs last.

424.03 -- Construction Methods

1. General:

a. Line Appearance. Markings shall essentially have a uniform cross section. The density and quality of markings shall be uniform throughout their thickness. The applied markings shall have no more than 5 percent, by area, of holes or voids and shall be free of blisters.

b. The pavement markings shall be placed at the alignment markings established on the roadway. Deviation from the alignment established shall not exceed 2 inches and, in addition, the deviation in alignment of the marking being placed shall not exceed 1 inch per 200 feet of roadway nor shall any deviation be abrupt.

c. Longitudinal markings shall be offset at least 2 inches from construction joints of portland cement concrete surfaces and joints and shoulder breaks of asphalt surfaces.

d. All permanent pavement markings shall be applied according to the manufacturer's instructions.

e. When deemed necessary by the Engineer to achieve specified alignment, the Contractor, at his/her expense, shall place any additional markings required to achieve the specified alignment throughout both straight and horizontally-curved sections of roadway. Any and all additional markings placed on the roadway for alignment purposes shall be temporary in nature and shall not establish a permanent marking on the roadway. Materials used

for alignment markings and equipment used to place such markings shall be approved by the Engineer.

f. The Contractor shall have on the project at all times during the application of the permanent pavement markings at least one employee with a valid "American Traffic Safety Services Association" (ATSSA) certification. The ATSSA certification may be for either a "Certified Pavement Marking Technician" or a "Certified Pavement Marking Specialist." The Contractor shall provide the Engineer a copy of the employee's certification prior to the beginning of work.

g. Prior to the installation of the permanent pavement marking, the Contractor shall provide to the Engineer a printed copy of the material manufacturer's installation procedures.

h. The pavement upon which the pavement markings are to be placed shall be cleaned and prepared in a manner and to the extent recommended by the manufacturer prior to placement of the markings. Cleaning shall be by any effective method, approved by the Engineer, that completely and effectively removes contaminants, loose materials, and conditions deleterious to proper adhesion without damaging the roadway.

i. Existing painted pavement markings on both concrete and asphalt pavement shall be removed prior to placement of the permanent markings. Existing durable pavement markings (plastic or old epoxy) shall be removed or prepared in a manner and to the extent recommended by the manufacturer prior to placement of the new markings. Conflicting lines shall be removed. The area of removal shall be the width needed for the new pavement marking and/or the existing line(s), whichever is greater.

2. "Durable Retroreflective Preformed Pavement Marking, Type _____ Grade _____":

a. The Contractor's liability will be limited to material replacement only for the amount of markings actually missing from the roadway.

b. The markings shall be applied in accordance with the manufacturer's recommendations. Marking configurations shall be in accordance with the *Manual on Uniform Traffic Control Devices*.

c. When markings are specified in the contract for newly paved asphaltic concrete surfaces, they shall be applied before public traffic is allowed on the freshly paved surface. Preferably, the markings should be inlaid in the fresh surface during final rolling of the mat; but in any case, they shall be applied before the close of the shift on the day which the surface is paved. These markings can also be overlaid on existing pavement surfaces.

d. (1) The Contractor and/or manufacturer shall provide application equipment, manual or automatic as necessary for the job requirements. These applicators shall be capable of applying two, 4 inch lines simultaneously with a 4 inch spacing between lines. These units shall be capable of applying an unlined, precoated, pressure sensitive adhesive pavement marking tape.

(2) The manual unit shall have manually actuated product feed advance system and a foot operated product cutting mechanism.

(3) The automatic unit shall have the capability of advancing, applying, and cutting the pavement marking tape at specific preprogrammed lengths at speeds up to 6.5 mph when towed by an appropriate vehicle.

3. Thermoplastic Pavement Marking:

a. Dirt, grease, or any foreign materials that would reduce the adhesion of the thermoplastic to the pavement must be removed by the Contractor before the application of thermoplastic material.

b. The Contractor shall check the pavement surface moisture each day prior to marking application as follows:

(1) Apply a thermoplastic line on a piece of tar paper (approximately 6 feet long) over the area to be striped.

(2) After 30 seconds, visually inspect the underside of the tar paper. If the underside is wet, **do not** install the thermoplastic.

(3) Another test for moisture is to place and hold a two square foot (0.2 m^2) piece of clear plastic on the existing pavement for a period of 15 to 20 minutes. Remove and hold the plastic in a vertical position, if water drips from the underside of the plastic sheet, the pavement has excess moisture. This will allow testing the pavement without waiting to heat up the thermoplastic.

c. A binder-sealer material, either epoxy, butadiene, styrene, neoprene, or others recommended by the thermoplastic manufacturer, must be applied in sufficient quantities to entirely cover the surface on which the marking is to be applied. This binder-sealer is required on all portland cement concrete pavement surfaces, as well as on all bituminous pavements over 60 days old.

d. Thermoplastic marking material shall not be applied until approval from the NDR Materials and Tests Division has been received. The Contractor is required to notify the appropriate District Construction Office 72 hours prior to the placement of the thermoplastic markings in order that an inspector can be present during the operation. At the time of this notification, the Contractor must indicate the manufacturer and lot numbers of thermoplastic and glass beads intended for use. A check should be made to insure that the approved lot numbers appear on the material package. Failure to do so is cause for rejection.

e. In no case shall thermoplastic pavement marking material be applied after November 15 or earlier than April 15 or when pavement or air temperatures are less than 50°F.

f. Thermoplastic material must be installed in a molten state between 450°F and 465°F.

g. Thermoplastic material must be installed at a thickness of not less than 1/8 inch or more than 0.188 inch. The initial measurement should be made above the pavement surface. In some cases, however, primarily on fresh bituminous concrete, the material may slightly penetrate the pavement.

h. If the material appears to be less than 1/8 inch thick above the pavement surface, the line shall be "chipped" and checked to determine the actual thickness. If the actual thickness is found to be less than 1/8 inch, the

deficient portions of the line shall be ground down to no more than 0.05 inch above the pavement surface and sufficient thermoplastic and glass beads placed over the line to bring it up to the specified thickness.

i. Thermoplastic material may be applied over the temporary painted edge line markings. Unless otherwise specified, 4 inch lines shall be laid a minimum of 2 inches from longitudinal joints.

j. Unless otherwise specified, pavement markings, words, and symbols shall be the *MUTCD* standard size. Deviations from reasonable standards of workmanship are cause for rejection.

k. Thermoplastic pavement marking material may be installed by the following methods:

(1) Extrusion Method:

This is basically a "slip form" method. As the applicator moves forward, a "die" or "shoe" with a fully-adjustable gate is dragged along the pavement to apply the material to the specified area.

(2) Ribbon Extrusion Method:

In this method, the hot thermoplastic material moves through a heated "block" where it drops through an orifice onto the pavement as the applicator moves forward.

l. Equipment used for placing markings shall be manufactured for that purpose and of sufficient size and stability to ensure a smooth and straight application for the following facility types:

(1) Freeways:

(i) A full-sized, truck-mounted unit capable of maintaining an operating speed of 3 to 5 mph is required. It must have the capability of automatically placing intermittent as well as continuous lines from either the left or right side of the vehicle. The vehicle shall be capable of applying either extrusion or ribbon thermoplastic in uniform dimensions and accurately following pavement irregularities.

(ii) The Engineer may allow the use of a hand-operated or small riding machine where a limited quantity of edge and lane lines are required, provided sufficient traffic control is in place to close the lane adjacent to the marking operations.

(2) Non-Freeway:

Thermoplastic pavement marking may be placed with either truck-mounted or hand-operated equipment. Small riding units are considered "hand-operated."

m. Reflectivity:

Immediate reflectivity is accomplished by the application of glass beads to the surface of the marking through a gun that is located directly behind the thermoplastic applicator. The beads should be dropped or sprayed into the material in a manner that will result in the surface beads being embedded to about their midpoint. Glass beads shall be applied uniformly at a minimum rate of 12 lb/100 SF. These beads are in addition to those that are provided as part of the thermoplastic mixture itself.

4. Thermoplastic Pavement Marking, Spray Type:

a. Application Equipment. All equipment for application of thermoplastic marking materials shall be of such design and maintained in such condition as to properly heat, mix and apply the materials.

b. Melting Kettle. The melting kettle shall be capable of heating the thermoplastic material to its recommended application temperature and maintaining that temperature without scorching. The heating kettle shall have a heat transfer medium, and the flame shall not come in direct contact with the material container surface. A temperature gauge shall be visible on the outside of the kettle to indicate the temperature of the thermoplastic material. The melting kettle shall have a continuous mixer or agitator capable of thoroughly mixing the material at such a rate as to maintain homogeneity of material and uniformity of temperature throughout.

c. Thermoplastic Dispensing Devices. The equipment shall be capable of applying molten thermoplastic material at the temperature recommended by the manufacturer of the thermoplastic material in lines from 4 inches to 12 inches wide at a 30 mils thickness. Dispensing devices shall be of the spray type.

d. Glass Bead Dispenser. The thermoplastic dispenser shall be equipped with a drop-on type glass bead dispenser. The glass bead dispenser shall be located so as to drop the glass beads immediately after the molten thermoplastic material is applied. The glass bead dispenser shall be adjustable to regulate the flow of the beads and shall uniformly dispense the glass beads over the entire width of the line.

e. Surface Preparation. The pavement surface on which the thermoplastic material is to be placed shall be clean and dry. Pavement surfaces shall be inspected for cleanliness and any dirt, debris, or other contaminants on the surface to be marked shall be removed as required by the manufacturer.

f. Temperature Limitations. The pavement surface where the thermoplastic material is to be placed shall have a minimum temperature of 50°F. The air temperature shall be at least 50°F during marking operations. The pavement surface temperature and air temperature shall be determined before the start of each day of marking operation and at any other time deemed necessary by the Engineer. Temperatures are to be obtained in accordance with MHTD Test Method T20.

g. Primer Application. A primer is not required on new bituminous surfaces unless recommended by the manufacturer of the thermoplastic material. If primer is recommended, it shall be applied and cured in accordance with the recommendations of the manufacturer of the thermoplastic material.

h. Thermoplastic Application. The thermoplastic marking material shall be sprayed onto the pavement surface.

i. The temperature of the thermoplastic material at the time of application shall be at least 350°F and less than 425°F. The temperature of the thermoplastic material shall be checked on the surface as it is placed with a calibrated thermometer at the beginning of each day's marking. Check the temperature after the material is added to the dispensing device, after delays in the marking operation, and any time deemed necessary by the Engineer.

j. Pavement striping shall comply with the standard striping practices shown on the plans. The Contractor shall begin centerline and lane line striping at the beginning of the last existing 10 foot stripe in order to maintain a 40 foot cycle along the entire pavement.

k. Finished markings shall have well defined edges, and lateral deviation shall not exceed 1 inch in 200 feet. The minimum thickness of thermoplastic markings shall be 30 mils and the maximum shall be 50 mils. The thickness will be measured as a wet film, except the Engineer may measure cured film by placing the thermoplastic material and then removing a section of cured line and measuring its thickness.

l. Damage to pavement marking caused by the Contractor's operation shall be repaired or replaced at his/her expense.

m. Glass Bead Application. The drop-on bead shall be mechanically deposited on the molten thermoplastic line immediately after placement of the thermoplastic at the rate of at least 18 lbs/100 SF. The glass beads shall not be dropped at the point of application of the thermoplastic or ahead of that point. The beads shall adhere to the cured thermoplastic, or all marking operations shall cease until corrections are made.

n. (1) Workmanship. The applied thermoplastic markings should be inspected continually for overall workmanship. Markings shall have clean cut edges. The glass beads shall appear uniform on the entire marking surface. Adhesion to the pavement surface shall be checked with a stiff putty knife or similar instrument. The marking should not be removable from a concrete surface. The marking can be removed from a bituminous surface; however, residue of the bituminous substrate shall be stuck to the marking material.

(2) If the thermoplastic line does not provide initial nighttime reflectivity or if the marking does not have the required minimum thickness, the Contractor shall, at no additional cost to the Department, apply additional thermoplastic material to obtain the total thickness specified. If the marking does not meet the required color, the Contractor shall, at no additional cost to the Department, remove the marking in a manner approved by the Engineer and re-apply the material. If the markings do not comply with the specifications for any other reason, the Engineer may require complete removal or correction at no additional cost to the Department.

5. Epoxy Pavement Marking

a. General

(1) The Contractor shall use a crew experienced in the work of installing epoxy pavement markings and shall supply all the equipment and materials necessary for the placement of the pavement markings.

(2) The epoxy pavement marking compound shall be applied with equipment that will precisely meter the two components in the ratio given. The equipment shall automatically shut off or warn the operator if one component is not being mixed. The equipment shall produce the required amount of heat at the mixing head and gun tip to provide and maintain the temperatures specified.

(3) Before mixing, the individual epoxy components A and B shall each be heated to a temperature of 80° F to 140° F (27°C to 60°C). After mixing, the application temperature for the combined material at the gun tip shall be 80° F to 140° F (27°C to 60°C). The 140° F (60°C) upper limit is the maximum temperature under any circumstances. Discard all material heated over 140° F (60°C).

(4) Both pavement and air temperatures shall be at least 4° F (4°C) at the time of epoxy pavement marking application. Application shall not be performed at pavement and air temperature below 40°F (4°C).

b. Material Purchase

(1) The Contractor shall field verify the pavement marking quantities required for the project prior to purchasing materials. The Department will not be held responsible for the Contractor's shortage or surplus of material. The Contractor's verification of quantities and purchasing material shall not delay the project or the installation of pavement marking when required.

c. Surface Preparation

(1) The surface areas of new Portland cement concrete pavement and decks that are to receive markings shall be sandblasted or shotblasted clean prior to placement of the epoxy pavement marking. The amount of blasting shall be sufficient to remove all dirt, laitance, and curing compound residue.

(2) Existing painted pavement markings on both concrete and asphalt pavement shall be removed prior to placement of the epoxy markings. Existing durable pavement markings (plastic or old epoxy) shall be removed or prepared in a manner and to the extent recommended by the manufacturer, prior to placement of the new epoxy markings. All conflicting lines shall be removed completely. Removal and preparation of existing pavement marking for the placement of the new epoxy shall be considered subsidiary to the pavement marking items.

(3) The surface areas of new asphalt pavement, existing asphalt pavement, and existing concrete pavement that are to receive markings shall be dry and cleaned with a high pressure air blast to remove loose material prior to placement of the epoxy pavement marking. Should any pavement become dirty, from tracked mud etc. as determined by the Engineer, it shall be cleaned prior to the placement of the epoxy pavement marking. All preparation of the roadway surface will be included in the bid price for this item.

(4) Epoxy pavement marking shall be applied to the road surface according to the epoxy manufacturer's recommended methods at 20 mils (500 µm) minimum thickness. Glass beads shall be applied on the epoxy using two bead dispenser. Immediately apply Type IV glass beads on the epoxy at a minimum rate of 12 lbs/gal (1.4 kg/l) of epoxy, immediately followed by an application of Type I glass beads at a minimum rate of 12 lbs/gal (1.4 kg/l).

(5) Epoxy pavement marking and beads shall be applied within the following limits:

Application Rate or Coverage
Per Gallon of Epoxy Pavement Marking

	Minimum	Maximum
20 mil (500 μm) Marking:	75 sq. ft. (7 m^2)	82 sq. ft. (7.6 m^2)
Beads: Type 4	12 lbs. (5.44 kg)	-
Type 1	12 lbs. (5.44 kg)	-

d. Protecting the Newly Installed Pavement Marking

(1) Paint lines, symbols and legends shall be protected from tracking during the setting period by one or more of the following methods:

(i) Cone off wet lanes from traffic.

(ii) Use of a convoy of moving vehicles to prevent traffic crossing the wet lines.

(iii) Saturate line or symbols and legends with glass beads to prevent tracking.

e. Alignment Adjustments

(1) The pavement markings shall be placed in proper alignment with guidelines established on the roadway. Deviation from the alignment established shall not exceed two inches (50 mm) and, in addition, the deviation in alignment of the marking being placed shall not exceed one inch per 200 feet (25 mm/60 m) of roadway nor shall any deviation be abrupt.

(2) When deemed necessary by the Engineer to achieve a specified alignment, the Contractor, at his expense, shall place any additional markings required to achieve alignment specified throughout both strait and horizontally-curved sections of roadway. Any and all additional marking placed on the roadway for alignment purposes shall be temporary in nature and shall not establish a permanent marking on the roadway. Materials used for the alignment markings and equipment used to place such markings shall be approved by the Engineer.

f. Defective Epoxy Traffic Stripes

(1) Epoxy traffic markings which after application and curing are determined by the Engineer to be defective and not in conformance with these Specifications shall be repaired. Repair of defective markings shall be made at the Contractor's expense and shall be performed to the satisfaction of the Engineer as follows:

(i) Insufficient film thickness, line width, glass bead coverage or retention.

(ii) Deficient glass bead coverage and/or retention shall be based on yield determinations made during installation and visual

comparison by the Engineer of newly applied field traffic markings to standard test plates manufactured in accordance with these Specifications.

(iii) Replacement method: Prepare the surface of the defective epoxy markings by grinding. No other cleaning methods will be permitted. Surface preparation shall be performed to the extent that substantial amount of the reflective glass beads are removed and a roughened epoxy marking surface remains.

(iv) Immediately after surface prepara-tion, remove loose particles and foreign debris by brooming and/or blasting with compressed air.

(v) Deficient curing, color or bond to substrate.

(vi) Uncured epoxy shall be defined as applied material that fails to cure(dry) in accordance with drying time (field) of this subsection.

(2) Repair shall be made by restriping over the cleaned surface, in accordance with the requirements of this specification and at a full 15 mil (380 μm) minimum line thickness.

(3) Discoloration shall be defined as localized areas or patches or brown or grayish colored epoxy marking material. These areas often occur in a cyclic pattern and, often are not visible until several days or weeks after markings are applied.

(4) Deficient bond shall be defined as any lack of adhesion (e.g. separation, chipping, cracking, etc.) between the new epoxy material and the substrate.

g. Observation Period

(1) Following initial completion of all pavement marking, there will be a 180 day observation period before final acceptance. During the observation period, the Contractor, at no expense to the Department of Roads, shall replace any marking that the Engineer determines are not performing satisfactorily due to defective materials and/or workmanship in manufacture and/or application. At the end of the observation period the minimum required retention percentage for marking installed shall be 90%.

(2) Determination of Percentage Retained - The percentage retained shall be calculated as the nominal area of the strip less the area of loss divided by the nominal area and expressed as a percentage of the nominal area.

(3) A claim, made by the State against the Contractor, shall be submitted to the Contractor in writing within 30 days after the 180-day observation period.

(4) When such a claim is made prior to August 1, the replacement material shall be installed during that same construction season. Replacement material for any claim after August 1, shall be installed prior to June 1, of the following year. Marking replacement shall be performed in accordance with requirement specified herein for the initial application, including but not limited to surface cleaning, sealer application, etc.

(5) Final acceptance of all marking will include an inspection of the appearance of the markings during daylight and darkness. Any markings that fail to have a satisfactory appearance during either period, as determined by the Engineer, shall be reapplied at no expense to the Department of Roads.

(6) Final acceptance of the pavement marking will be: (1) 180 days after the initial completion of all work, or (2) upon completion of all corrective work, whichever occurs last.

6. Preformed Pavement Marking Tape, Type 4 in Grooved Pavement

a. The permanent preformed pavement marking, Type 4 white dashed lines on this project, shall be applied to the pavement in Contractor installed grooves.

b. The grooves shall be made in a single pass dry cut using stacked diamond cutting heads, the equipment used shall be self vacuuming and leave the cut groove ready for tape installation. The equipment and method used shall be approved by the tape manufacture. The bottom of the groove shall have a fine corduroy finish. If a course, tooth pattern is present, increase the number of blades and decrease the spacers on the cutting head. The pavement marking tape shall be placed in the grooves the same day as the cut. Grooves shall be clean and dry prior to tape application. All conflicting pavement markings remaining after tape installation shall be removed, this removal shall be subsidiary to the pavement marking

Groove width:	tape width + 1 inch ± 1/8 inch (25 mm ± 3 mm)
Groove depth:	50 mils # 5 mils (1270 µm ± 125 µm)
Groove length:	full length of tape + required grooving transition
Groove position:	2 inches (50 mm) left of joint line

7. Permanent Pavement Marking Paint

a. The work of Permanent Pavement Marking shall consist of painting centerline, lane lines, no-passing zone lines, barrier lines and edgelines at the locations detailed in the plans and these special provisions or as directed by the Engineer. These Specifications cover the application of traffic paint and drop-on floating conventional beads on bituminous or portland cement concrete pavements.

b. Equipment

(1) The striper used for applying traffic marking paint and beads shall be self-propelled. The striper used for pavement marking shall:

(i) Be capable of applying three lines simultaneously on the left side for centerline markings and/or one line on the right side of the unit for edgeline markings.

(ii) Be capable of applying the traffic marking paint the width specified in the plans and to a dry thickness of 12± 1 mils (300 µm ±25 µm) that is uniform across the width and length of the stripe.

(iii) The reservoirs shall keep the paint mixture smooth and even.

(iv) Be equipped with an automatic skip device that applies a stripe and gap of a specified length with a tolerance of 3 inches (75 mm) per cycle of skip. This tolerance shall not be accumulated in subsequent cycles. The striper shall be able to adjust the cycle while striping to allow for matching the existing stripe.

(v) Be capable of applying the traffic marking beads to the wet paint immediately after the application of the paint at a rate required in the plans and these special provisions. The bead applicator shall be equipped with an automatic shut off synchronized with the paint flow.

(2) The trailing vehicles must be capable of carrying the traffic control as shown in the plans.

c. Pavement Surface Preparation. The roadway to be striped shall be cleaned of foreign matter that would prevent the paint from adhering to the roadway. The paint shall be applied to a dry pavement surface.

d. The Contractor shall supply as a minimum the traffic control shown in the plans. Variations to the traffic control plans shall be submitted in writing to the Engineer. No changes may be instituted until approved in writing by the Engineer. Traffic shall be maintained through the work area at all times. Traffic shall be controlled through the work area until the pavement markings have dried sufficiently to prevent tracking. Traffic control cones may be necessary in some cases to prevent tracking of the paint.

e. Application of Marking Materials.

(1) Pavement marking materials as specified shall be applied with equipment meeting the Specifications above. Where an irregular area is to be painted, hand sprayers and manual bead application is acceptable. Paint shall be applied within the manufacturer's recommended ambient temperature range unless otherwise ordered by the Engineer in writing. The paint shall not be applied when wind prevents the Contractor from placing markings acceptable to the Engineer. Striping shall be performed only during daylight hours.

(2) The beads shall be applied at the rate of 6 pounds per gallon (0.7 kg/l) of paint applied. If application rates are not within the requirements, the marking application shall be stopped until corrections are made.

(3) The paint shall be applied in such a manner as to follow the existing lines on the roadway or as directed by the Engineer. No-passing zones shall be laid out in advance of the striping by the Contractor with information provided by the Engineer. When deemed necessary by the Engineer to achieve the correct alignment the Contractor shall, at no additional cost, place additional markings to guide the placement of the lane lines. The guide markings shall be temporary in nature and the material and equipment used to place these guide markings shall be approved by the Engineer. The paint shall have a dry thickness of 12± 1 mils (300 µm ±25 µm) and shall be the width shown in the plans ±1/2" (12 mm). The Engineer will take periodic

samples to ensure the thickness and width of the stripe. Finished lines shall have well defined edges and lateral deviations shall not exceed 2 inches in 200 feet (50 mm in 60 m). The dashed lines shall be within 3 inches (75 mm) of their intended length and intended placement. When placing new lines, the cycle of dashed line and gap shall not vary more than 3 inches (75 mm). This tolerance shall not be accumulated in subsequent cycles. Lines not meeting these requirements may, at the discretion of the Engineer, be ordered removed and replaced at no cost to the State. Permanent pavement markings damaged by the Contractor's operation shall be repaired at the Contractor's cost.

424.04 -- Method of Measurement

1. All permanent pavement marking is measured as follows:

   a. Arrows and legends are measured by the each.

   b. Lines are measured by the linear foot of material installed for each width of lines installed. Gaps between line segments are not measured.

2. The preformed pavement marking tape, Type IV installed in grooves shall be measured and paid for by the linear foot (meter) of actual pavement marking material installed.

3. Permanent Pavement Marking Paint and Beads will be measured by the nominal length, excluding gaps, of line applied and accepted by the Engineer. The beads shall be subsidiary to items for which direct payment is made. Any striping ordered removed and replaced shall be done at no expense to the Department. The pay item is "Permanent Pavement Marking Paint" and the unit of measurement is Linear Foot (LF) [Meter (m)].

4. All temporary traffic control required for this work, with the exception of flagging if required by the Engineer, is subsidiary to items for which direct payment is made.

424.05 -- Basis of Payment

1. **Pay Item** | **Pay Unit**

_____ inch _____ Preformed Pavement Marking, Type _____	Linear Foot (LF)
_____ Preformed Pavement Marking, Type _____	Each (ea)
_____ inch _____ Thermoplastic	Linear Foot (LF)
_____ Thermoplastic	Each (ea)
_____ inch _____ Thermoplastic, Type _____	Linear Foot (LF)
_____ Thermoplastic Type _____	Each (ea)
Permanent Paving Marking, Paint	Linear Foot (LF) [Meter (m)]
____ Inch (mm) ____ Preformed Pavement Marking, Type IV Grooved	Linear Foot (LF) [Meter (m)]
Preformed Pavement Marking, Type IV Grooved	Each (Ea)
_____ Inch (mm) _____ Epoxy	Linear Foot (LF) [Meter (m)]
_____ Epoxy	Each (Ea)

2. Removal or preparation of existing pavement marking for the placement of the new material shall be considered subsidiary to the pavement marking items.

3. Payment is full compensation for all work prescribed in this Section.